

1/31

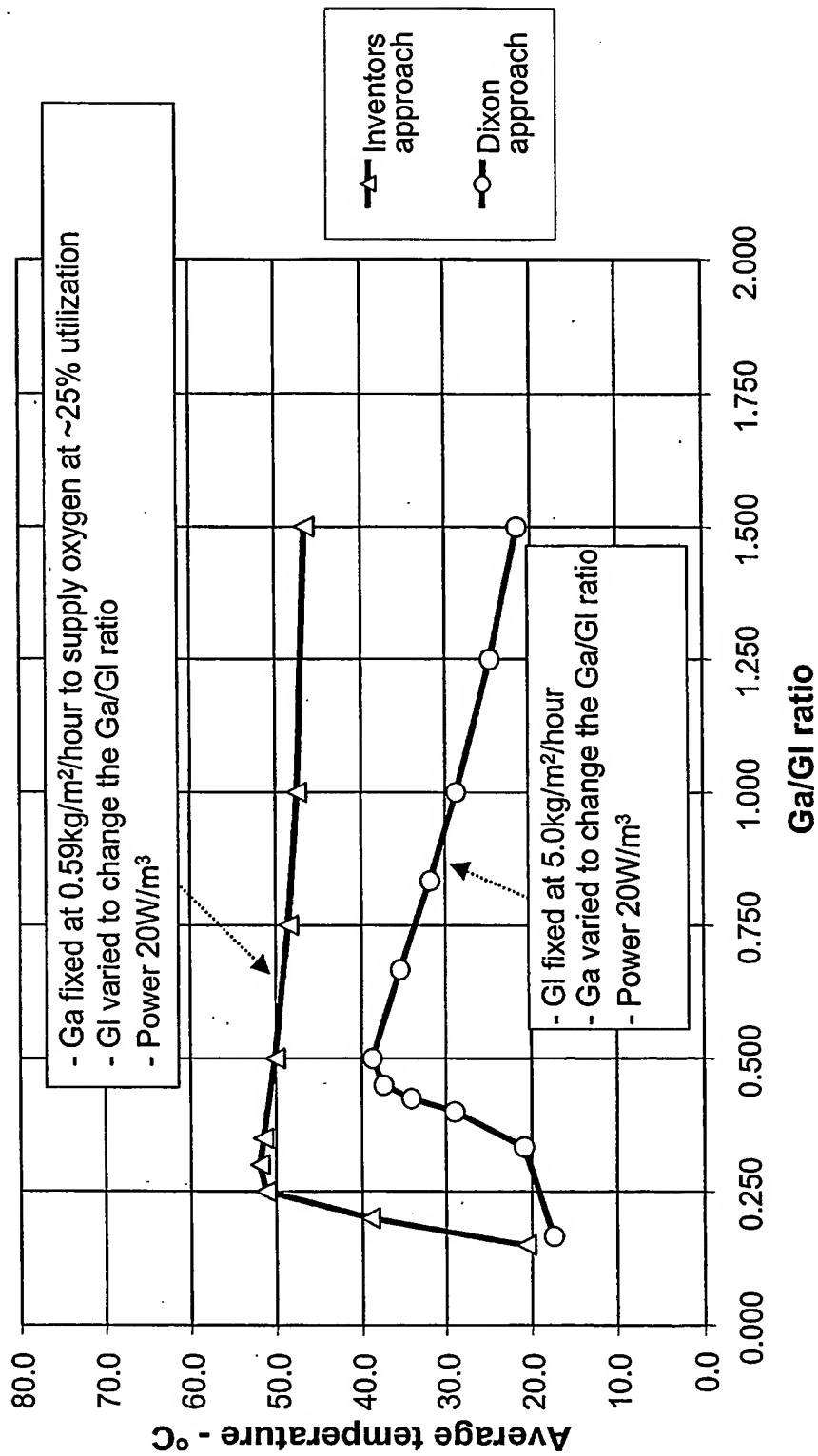


Figure 1 – Average heap temperature

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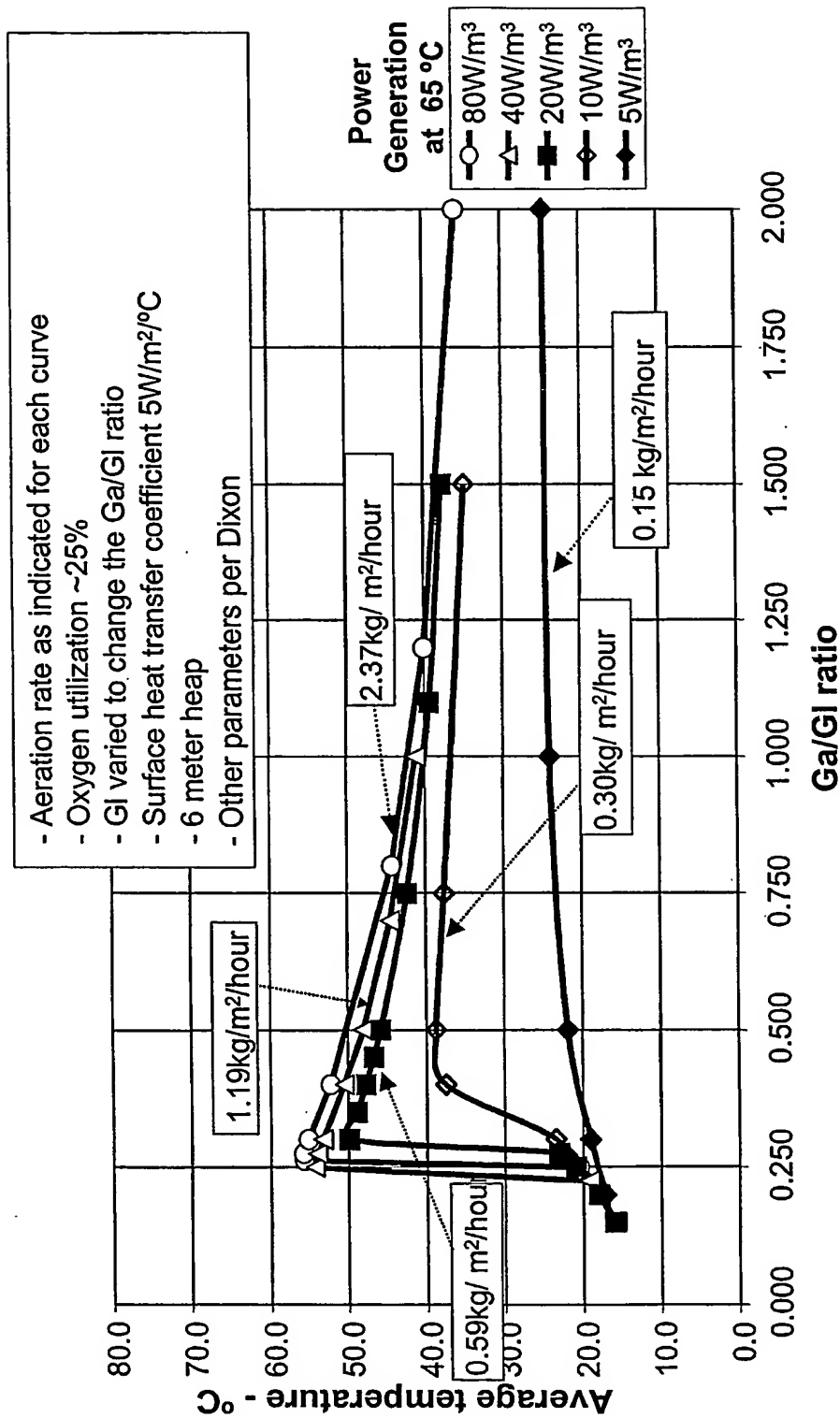


Figure 2 – Average heap temperature as a function of unit power generation

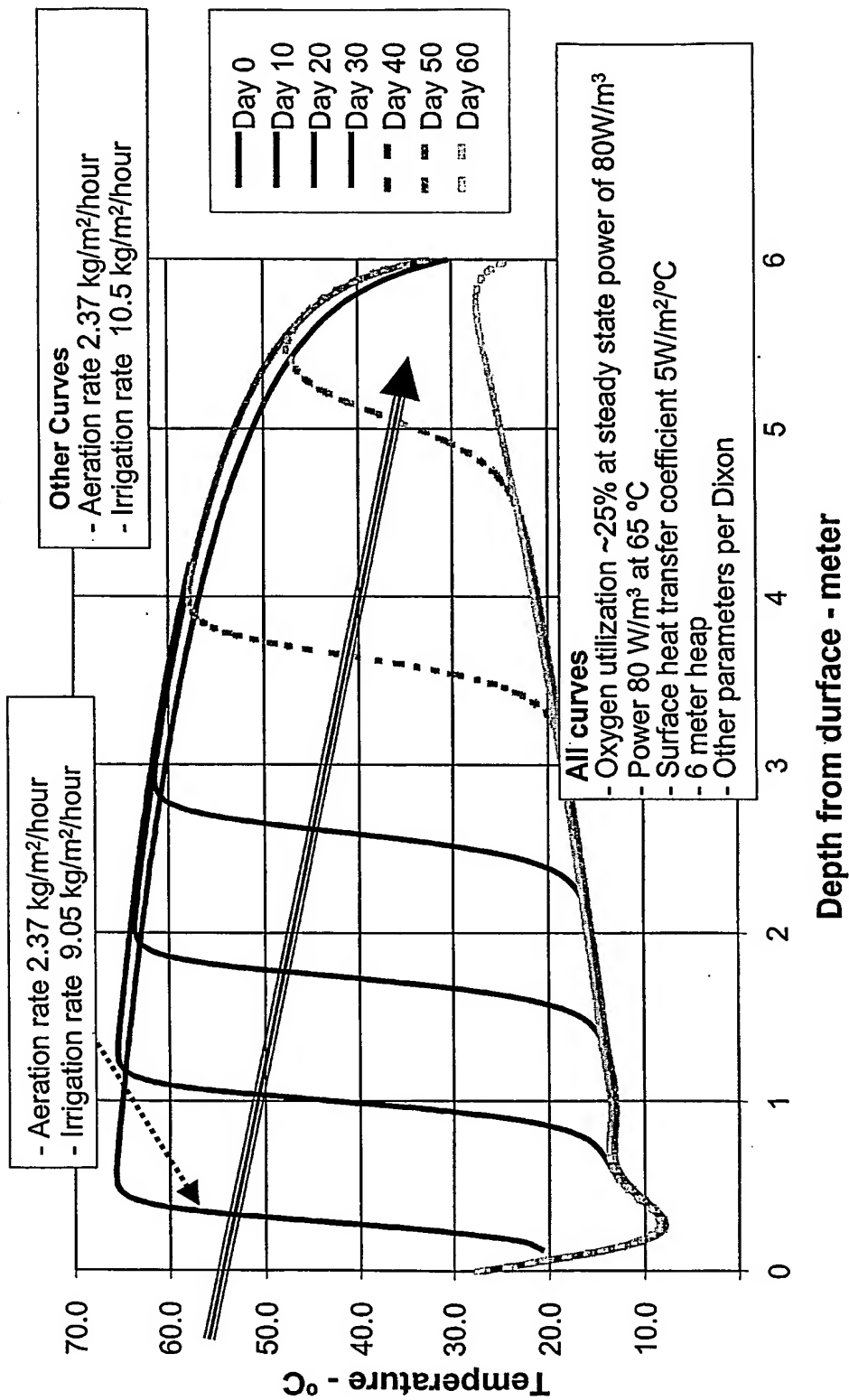


Figure 3 – Collapse of heap temperature below critical Ga/GI ratio

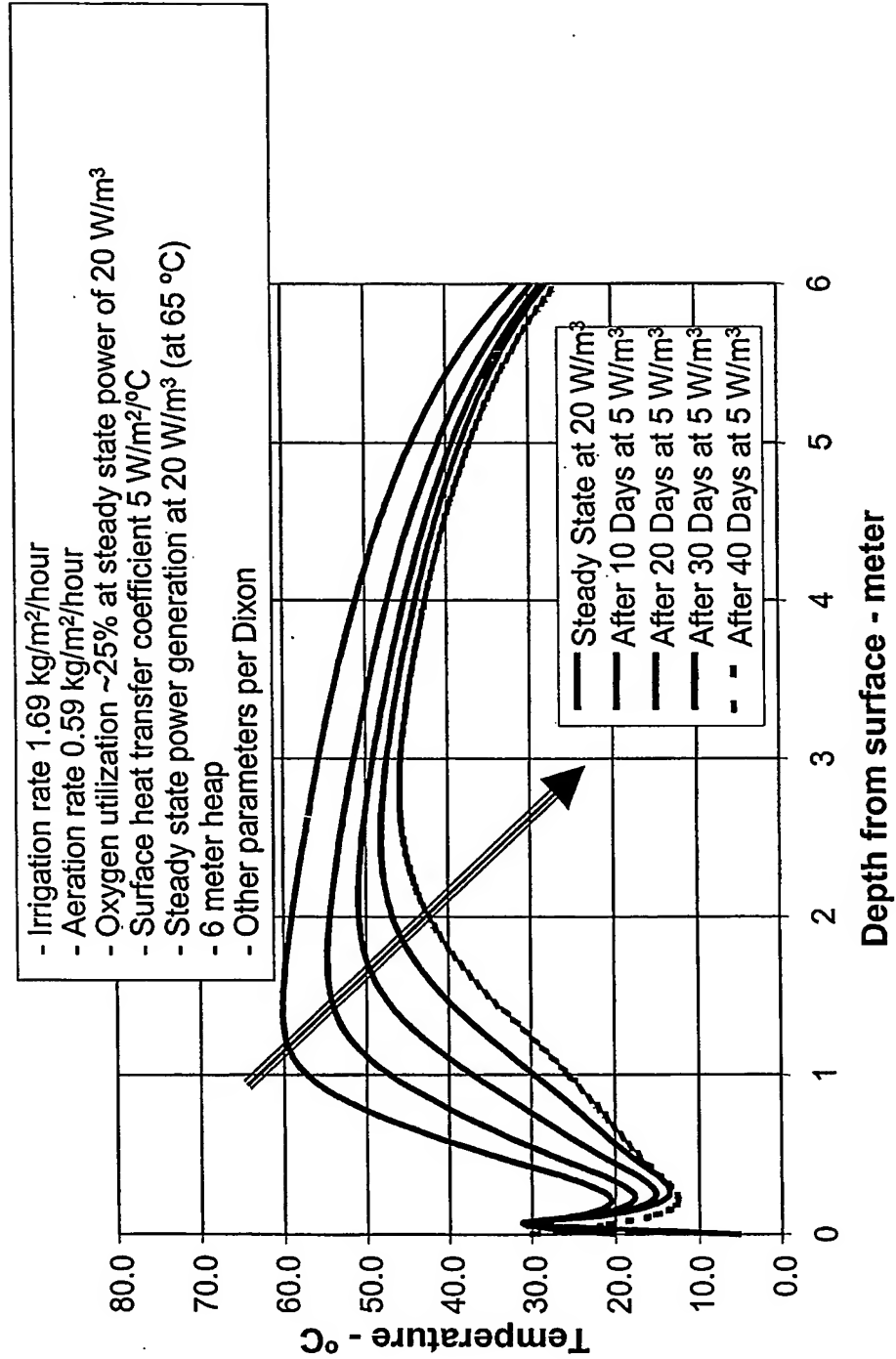


Figure 4 – Effect on steady state heap temperature profile with a step change down in power generation

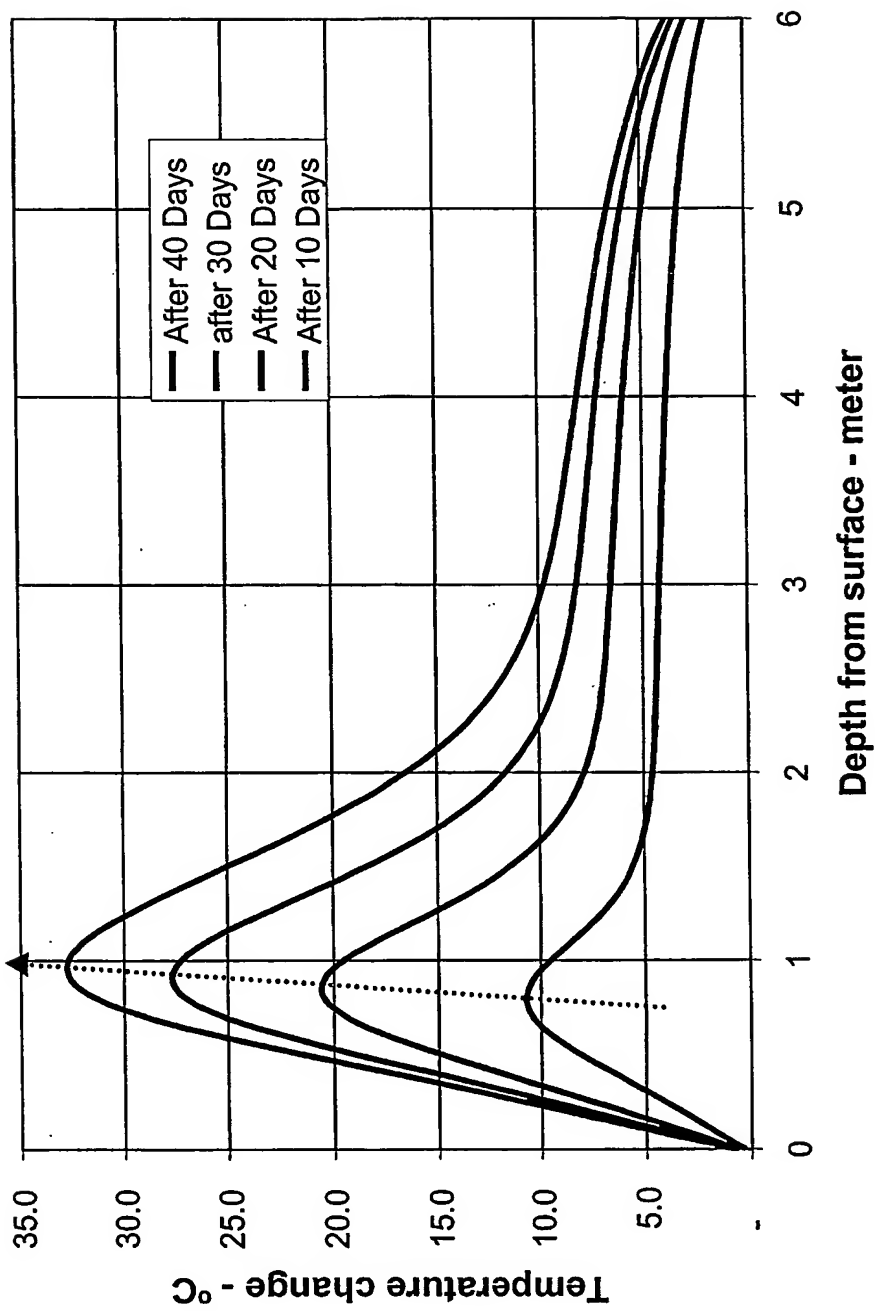


Figure 5 – Change in temperature at different depths after a step change down in power generation shown in Figure 4

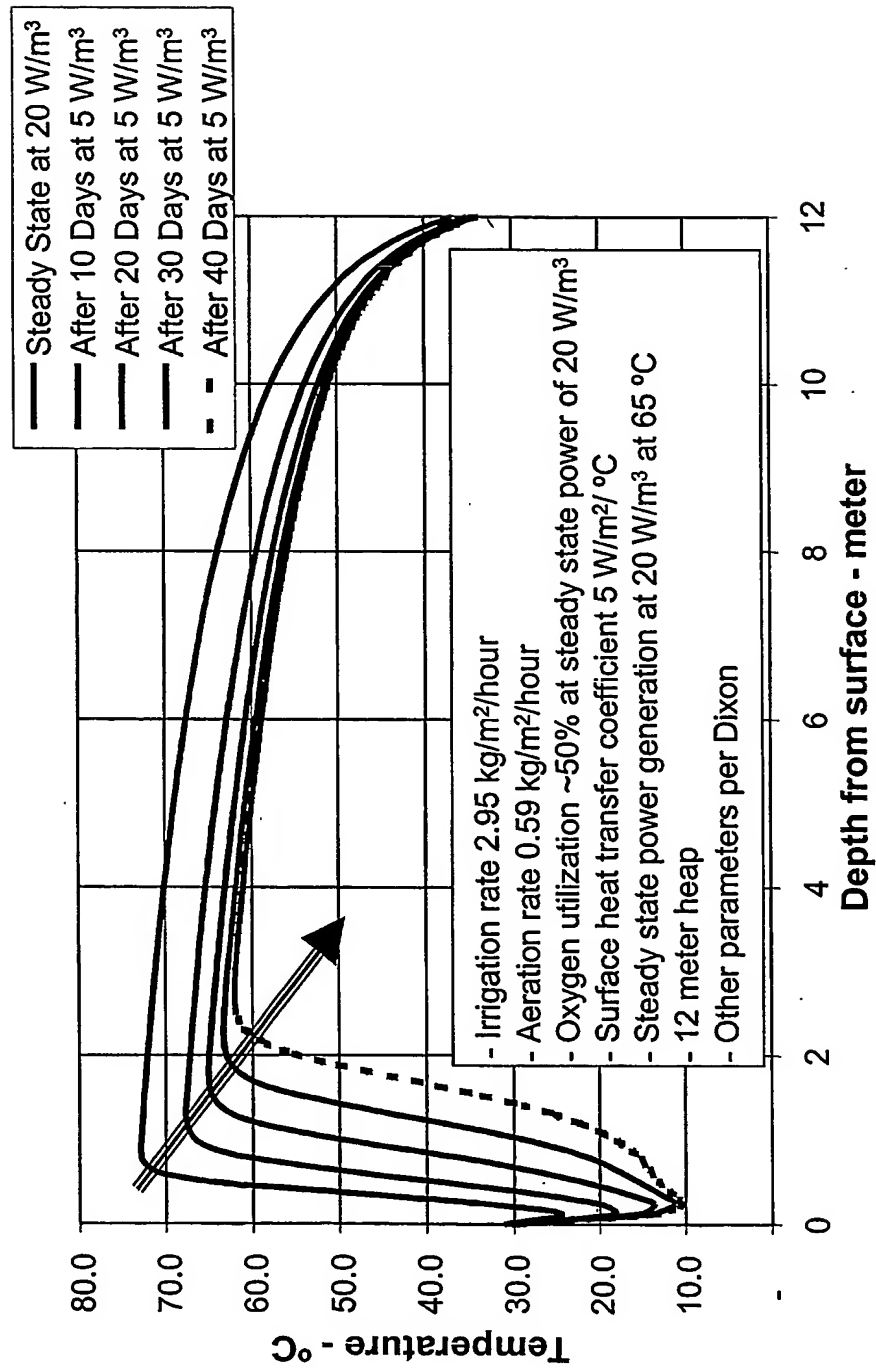


Figure 6 – Effect on steady state heap temperature profile with a step change down in power generation

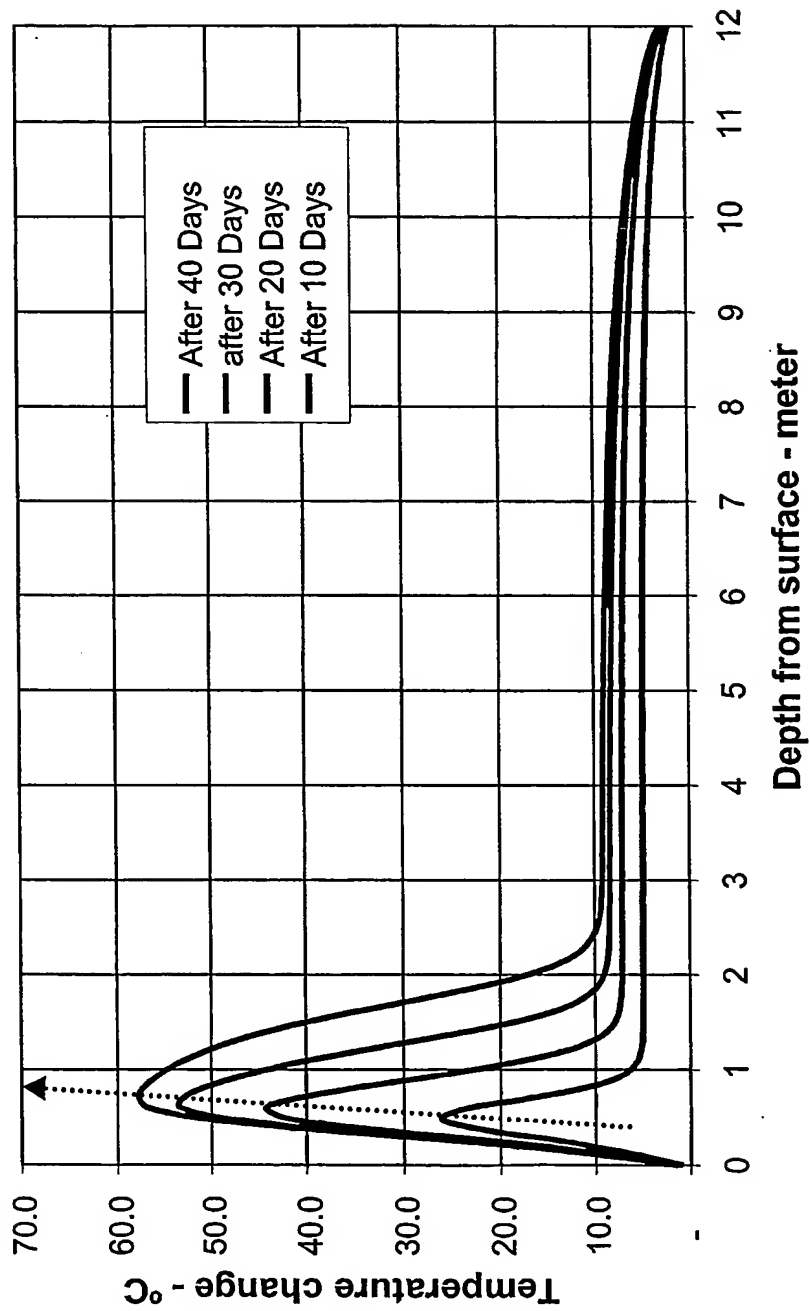


Figure 7 -- Change in temperature at different depths after a step change down in power generation as shown in Figure 6

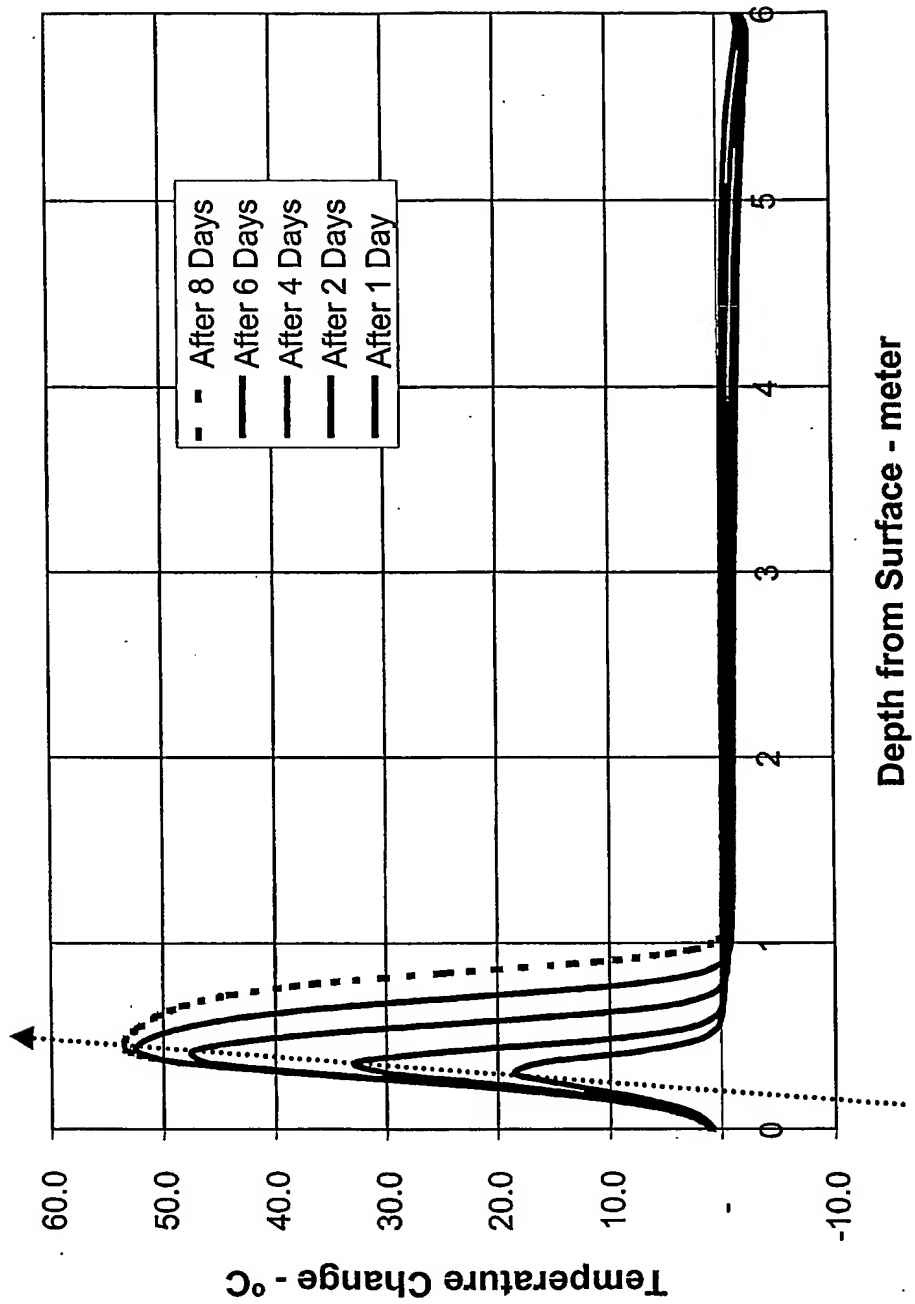


Figure 8 – Change in temperature at different depths after reduction in Ga/GI ratio shown in Figure 3



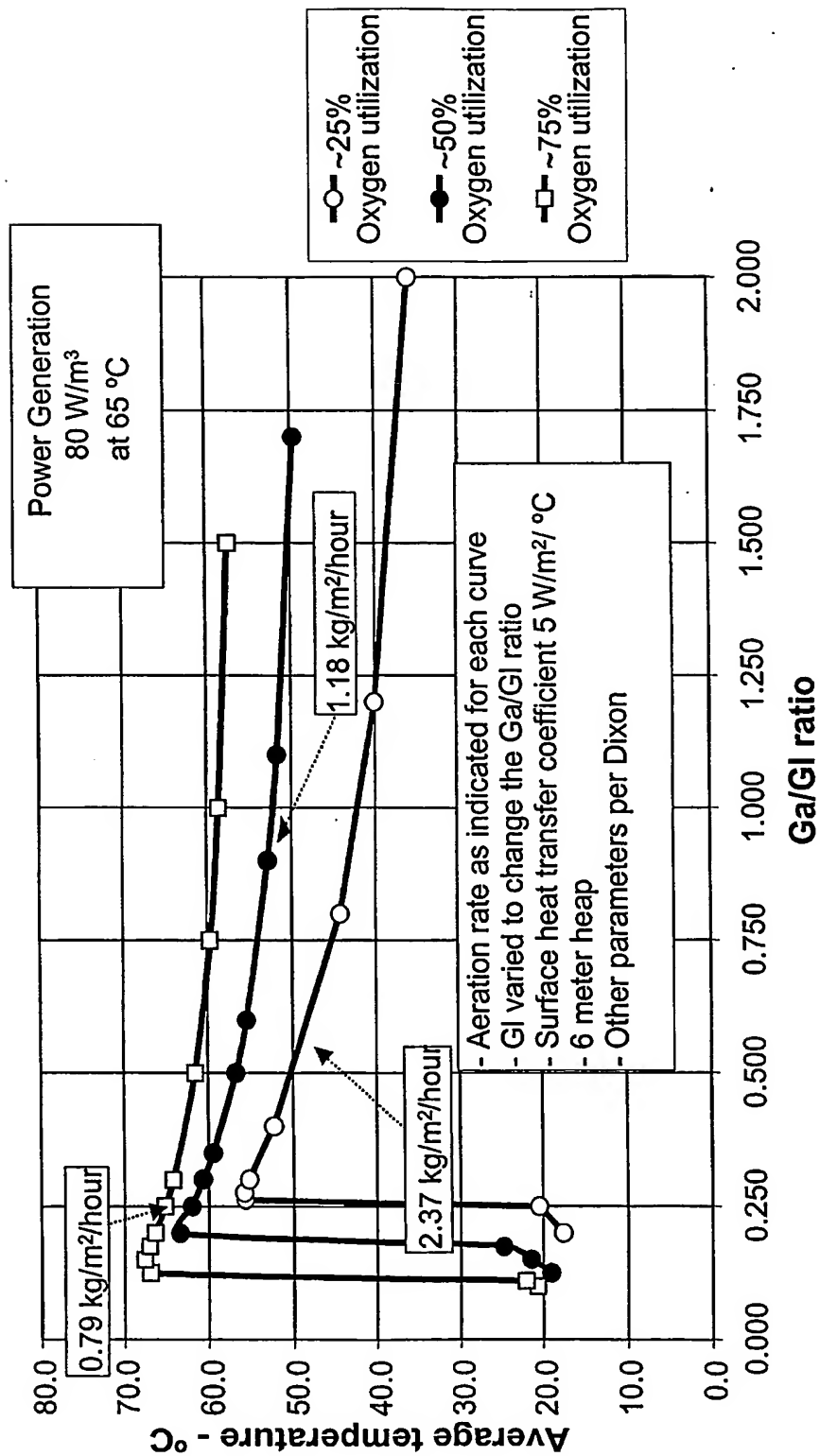


Figure 9 – Average heap temperature as a function of oxygen utilization

10/31

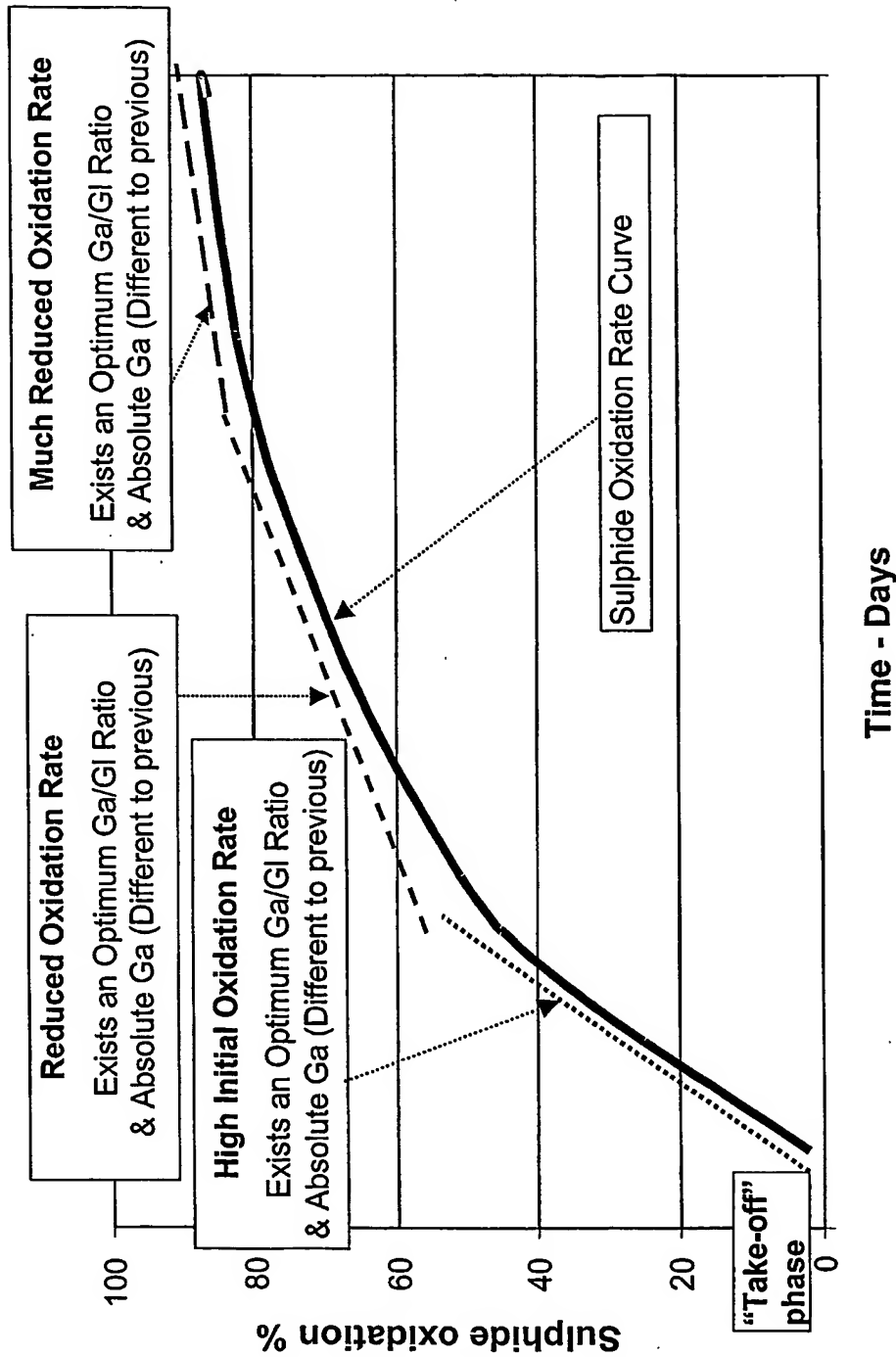


Figure 10 – Sulphide oxidation rates vary with time

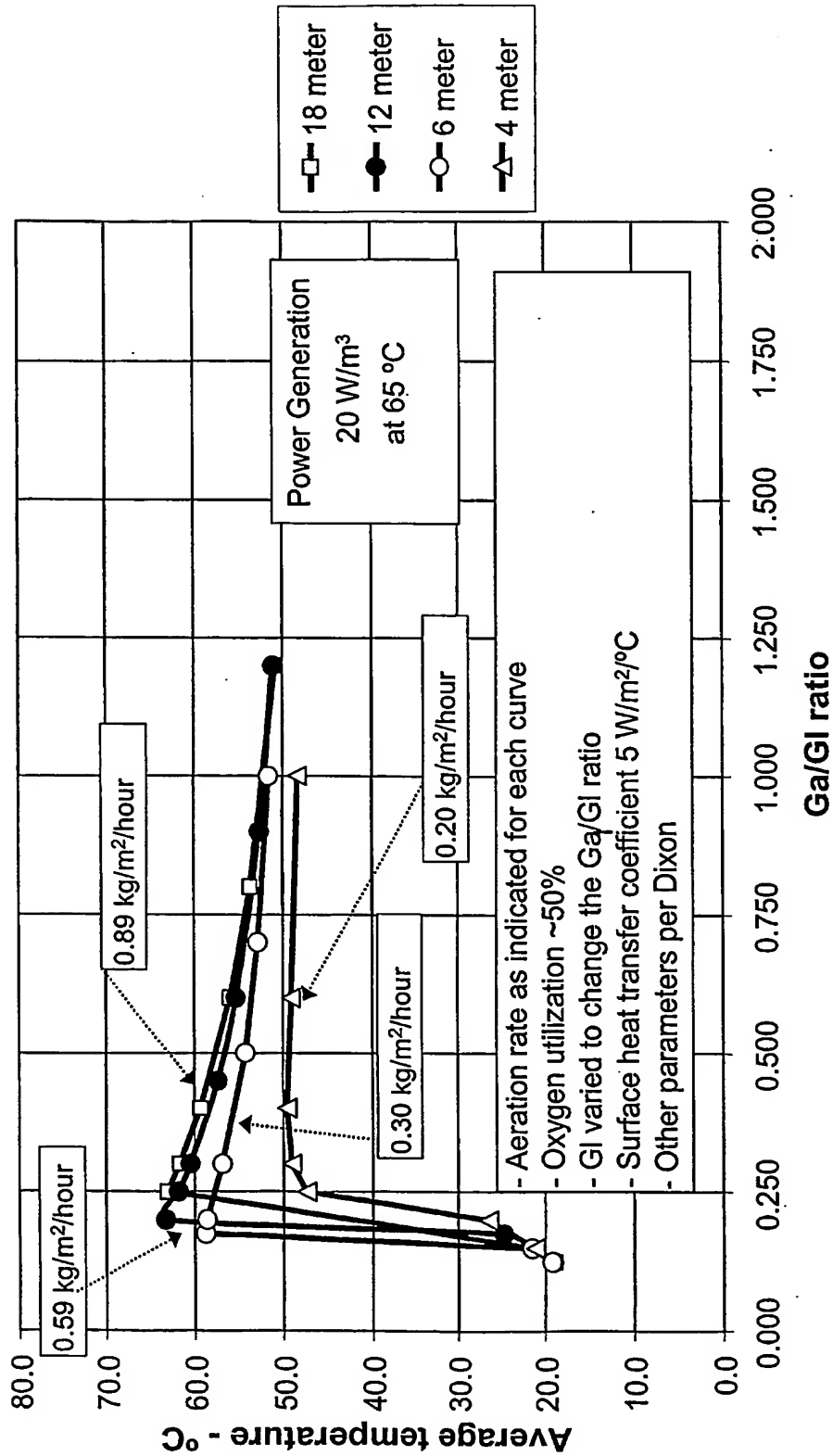


Figure 11 – Effect of heap height on average heap temperature

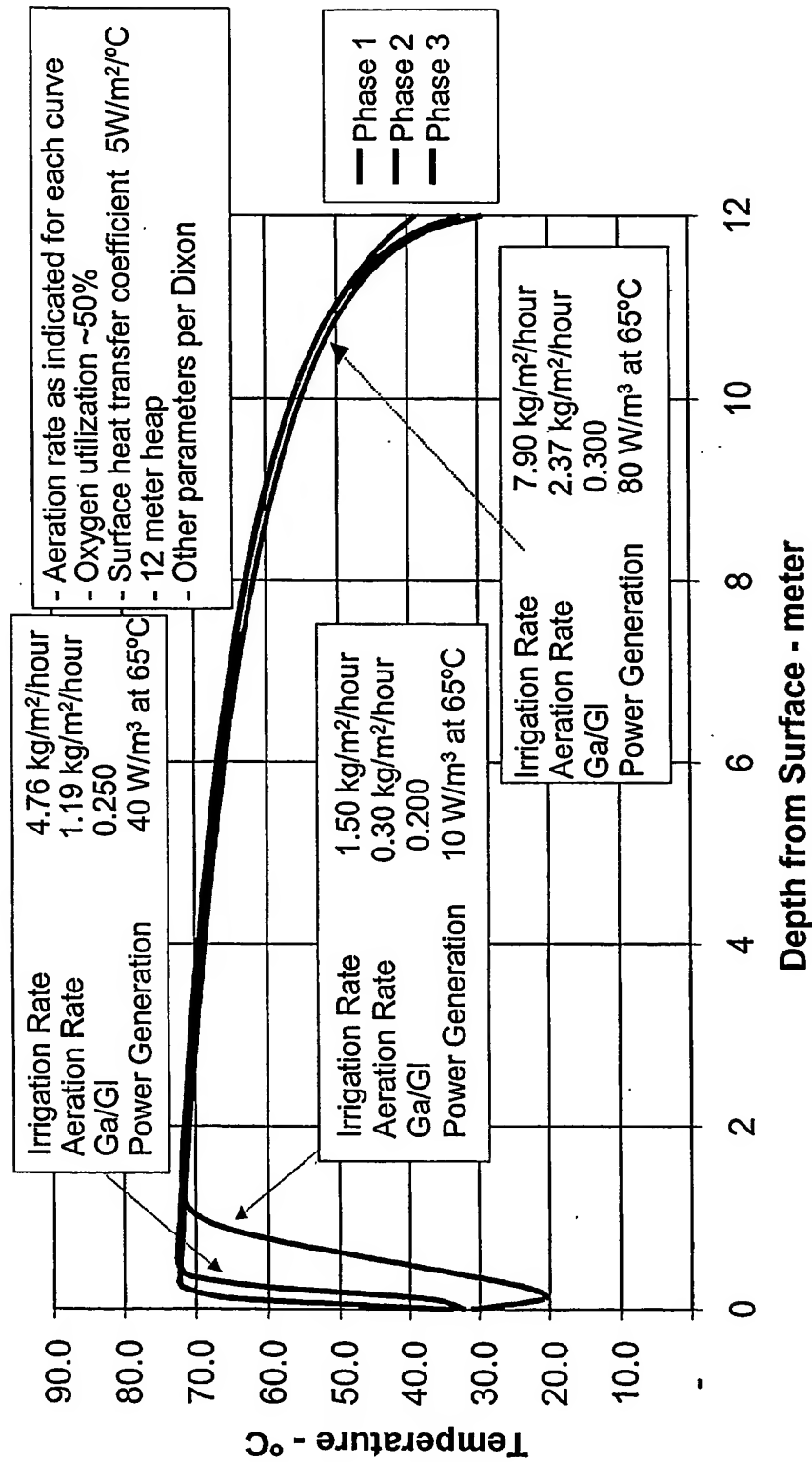


Figure 12 – Heap operating example, moderate sulphide oxidation rates

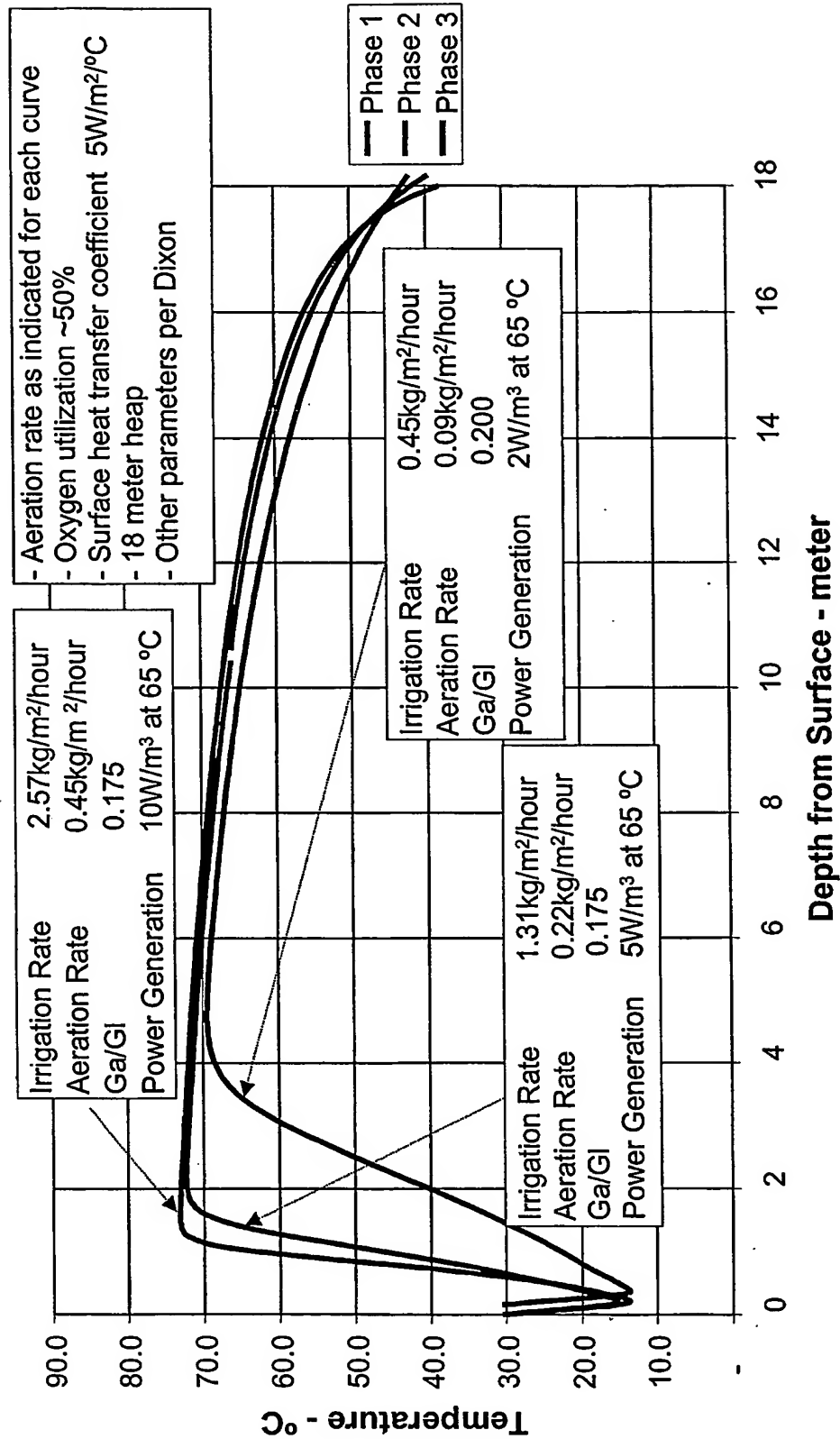


Figure 13 – Heap operating example, low sulphide oxidation rates

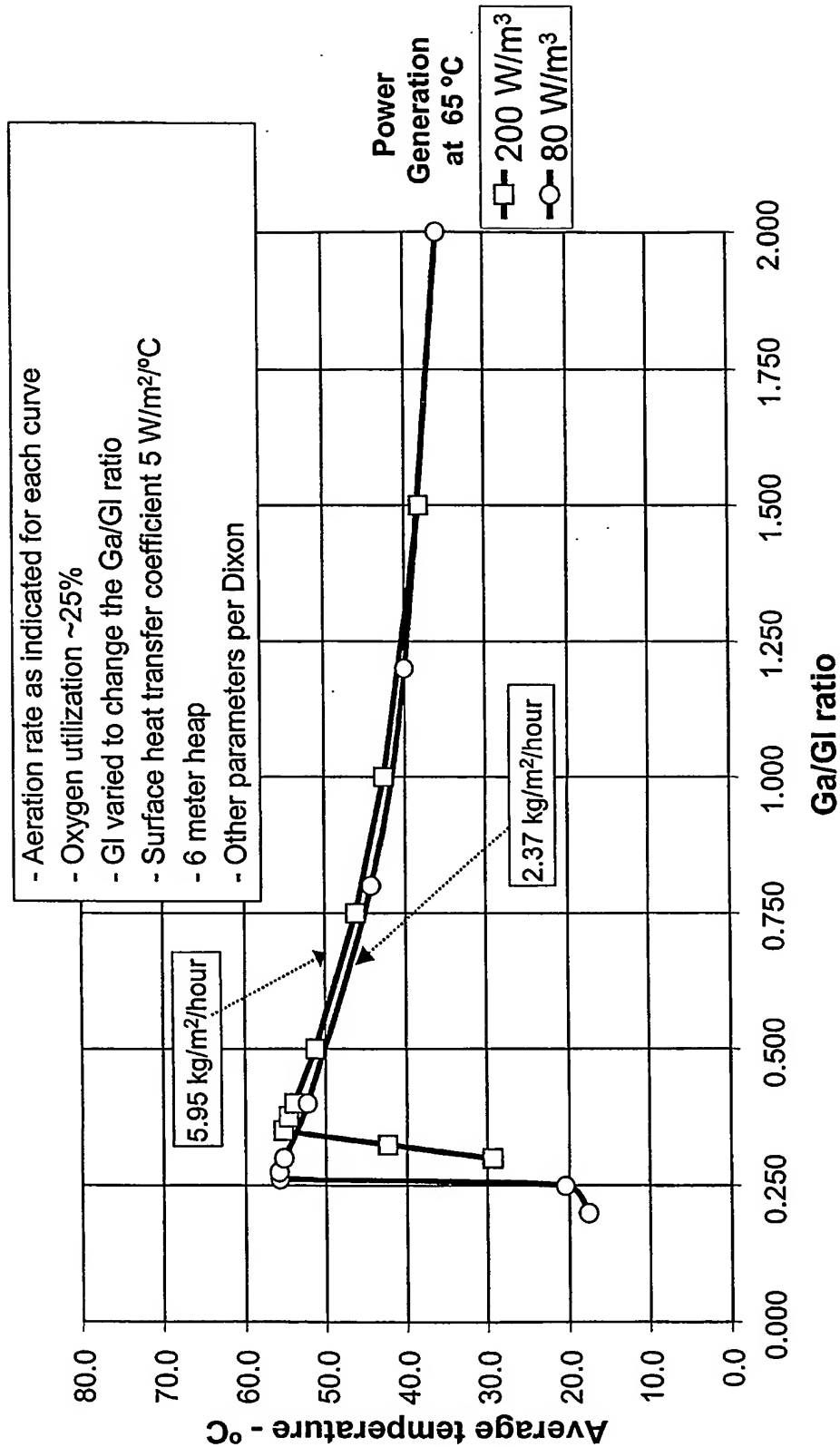
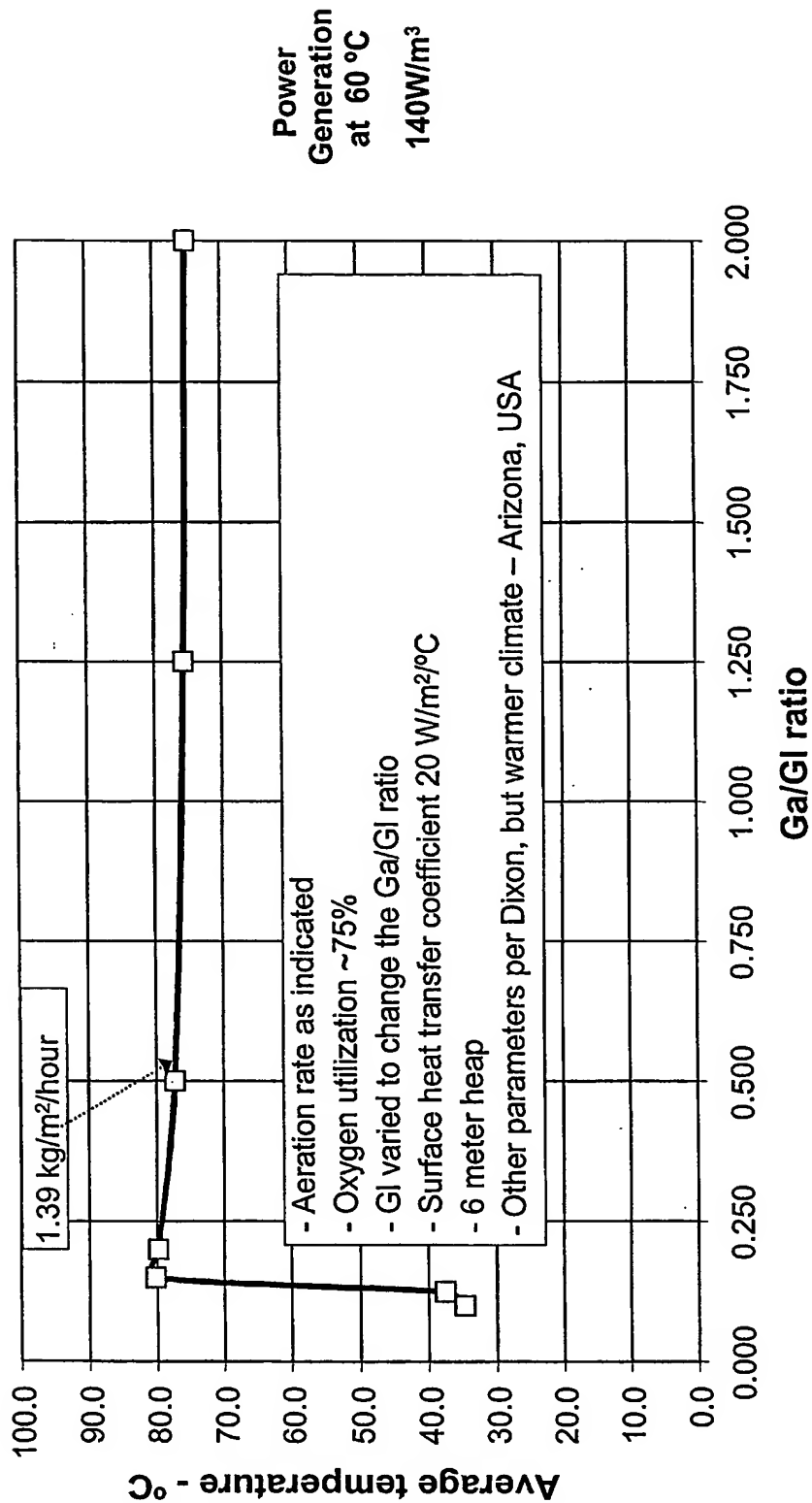
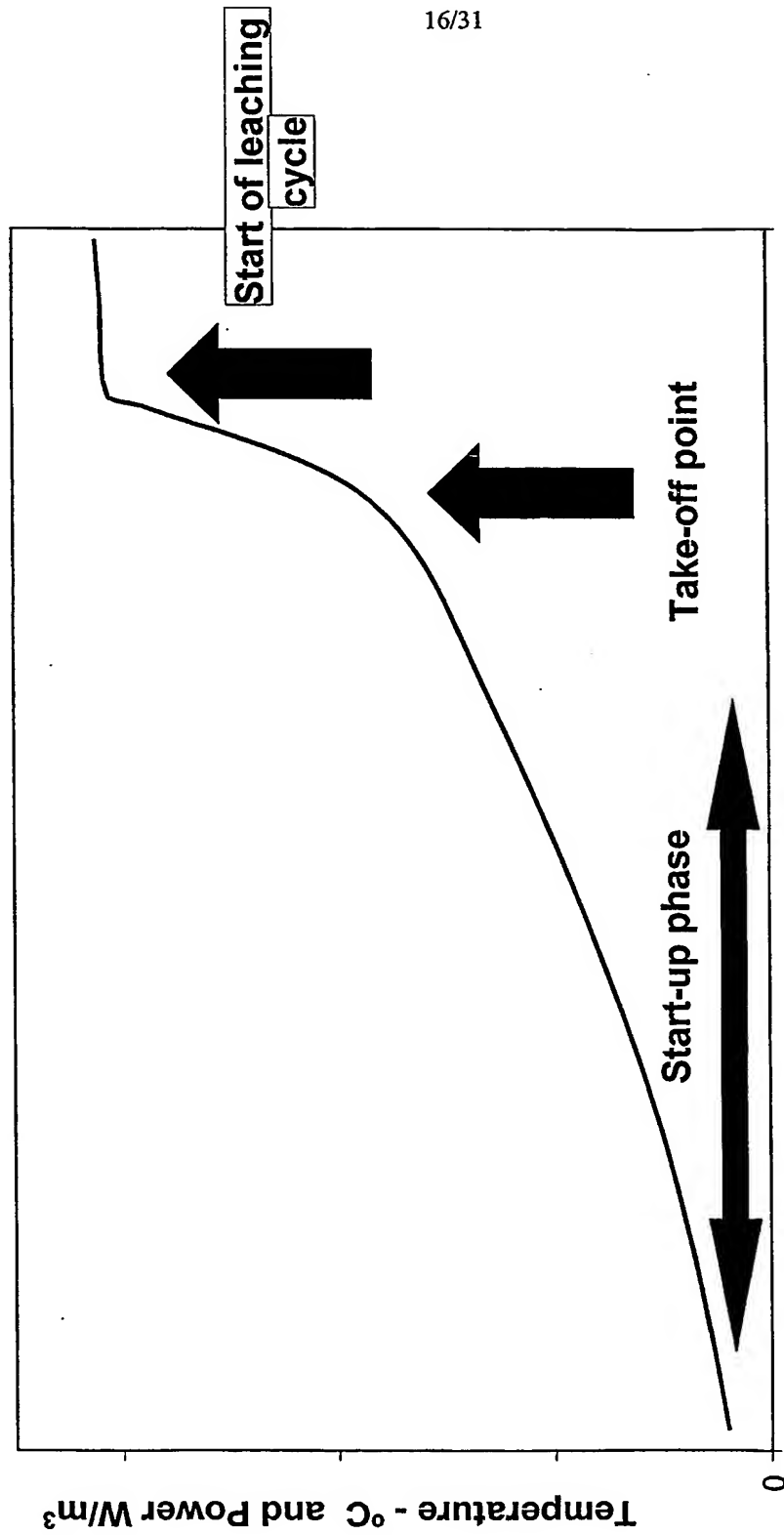


Figure 14 – Average heap temperature, high sulphide oxidation rates



**Figure 15 – Average heap temperature, 140W/m<sup>3</sup> power generation and 75% oxygen utilization**



Time - Days  
Figure 16 – Starting a heap: Getting to the take-off point



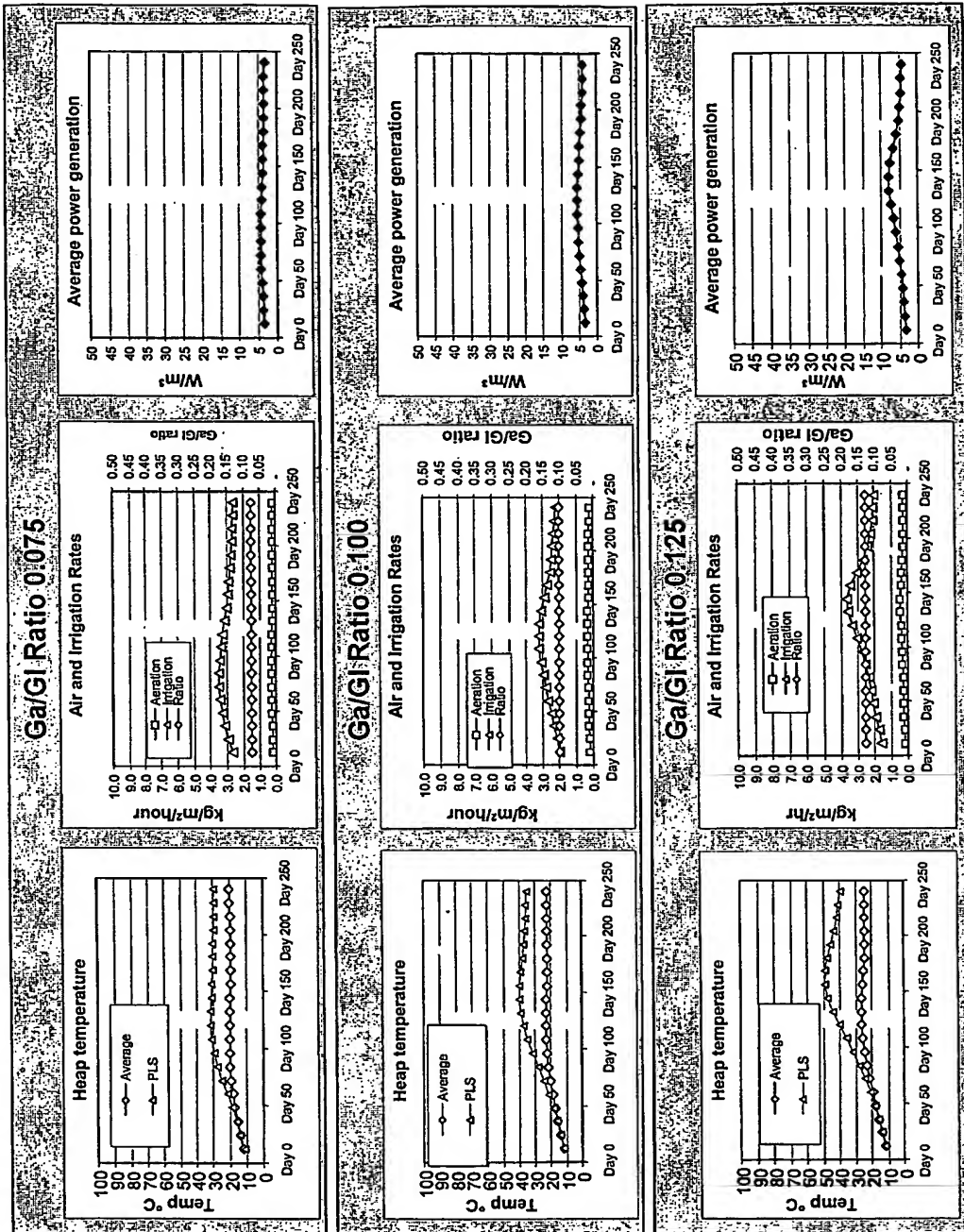


Figure 17 – Sensitivity of take-off to Ga/GI ratio in a mixed copper ore

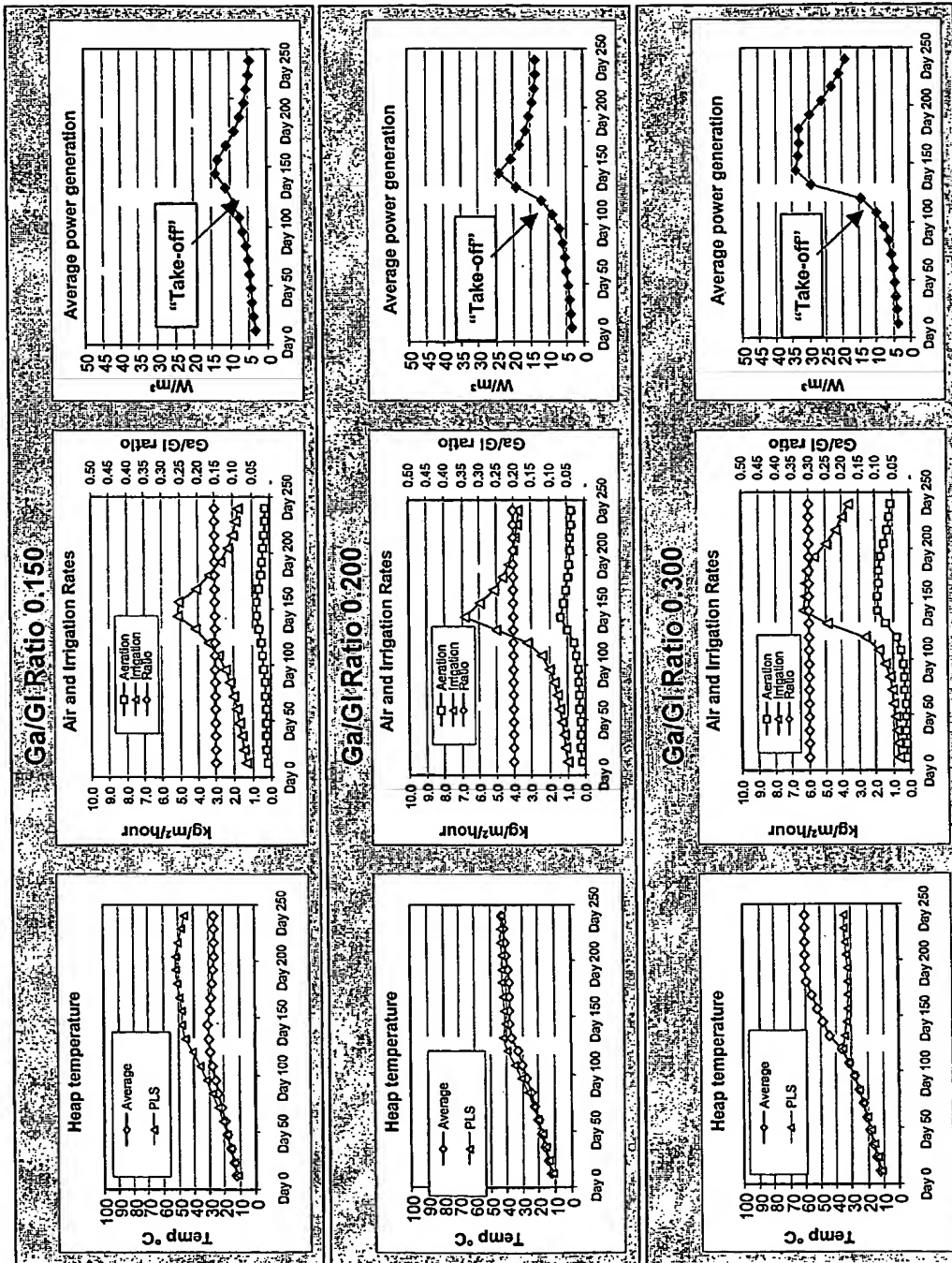


Figure 18 – Sensitivity of take-off to Ga/GI ratio in a mixed copper ore

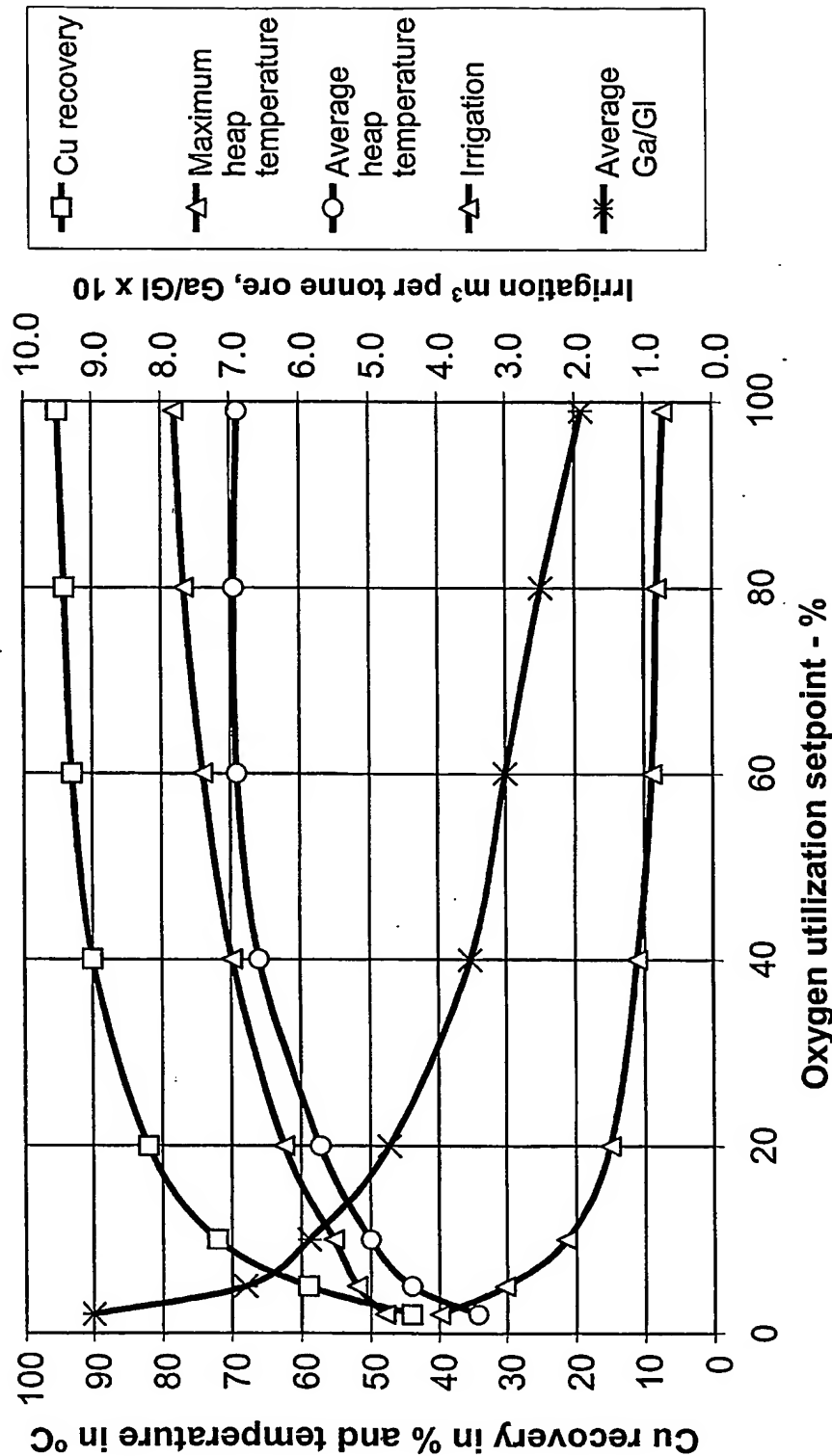


Figure 19 – Effect of oxygen utilization setpoint on Cu recovery, irrigation, Ga/GI ratio and heap temperature

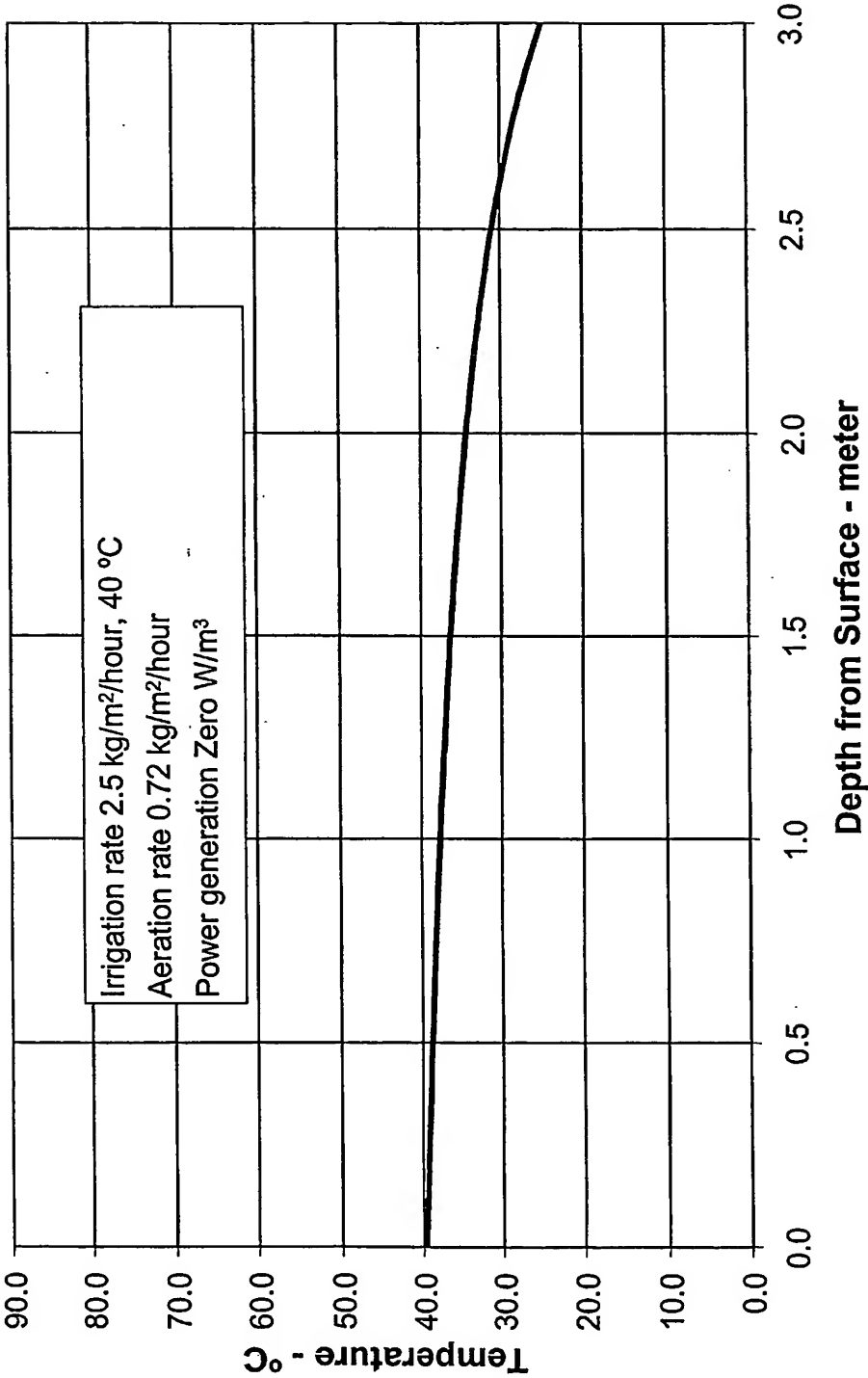
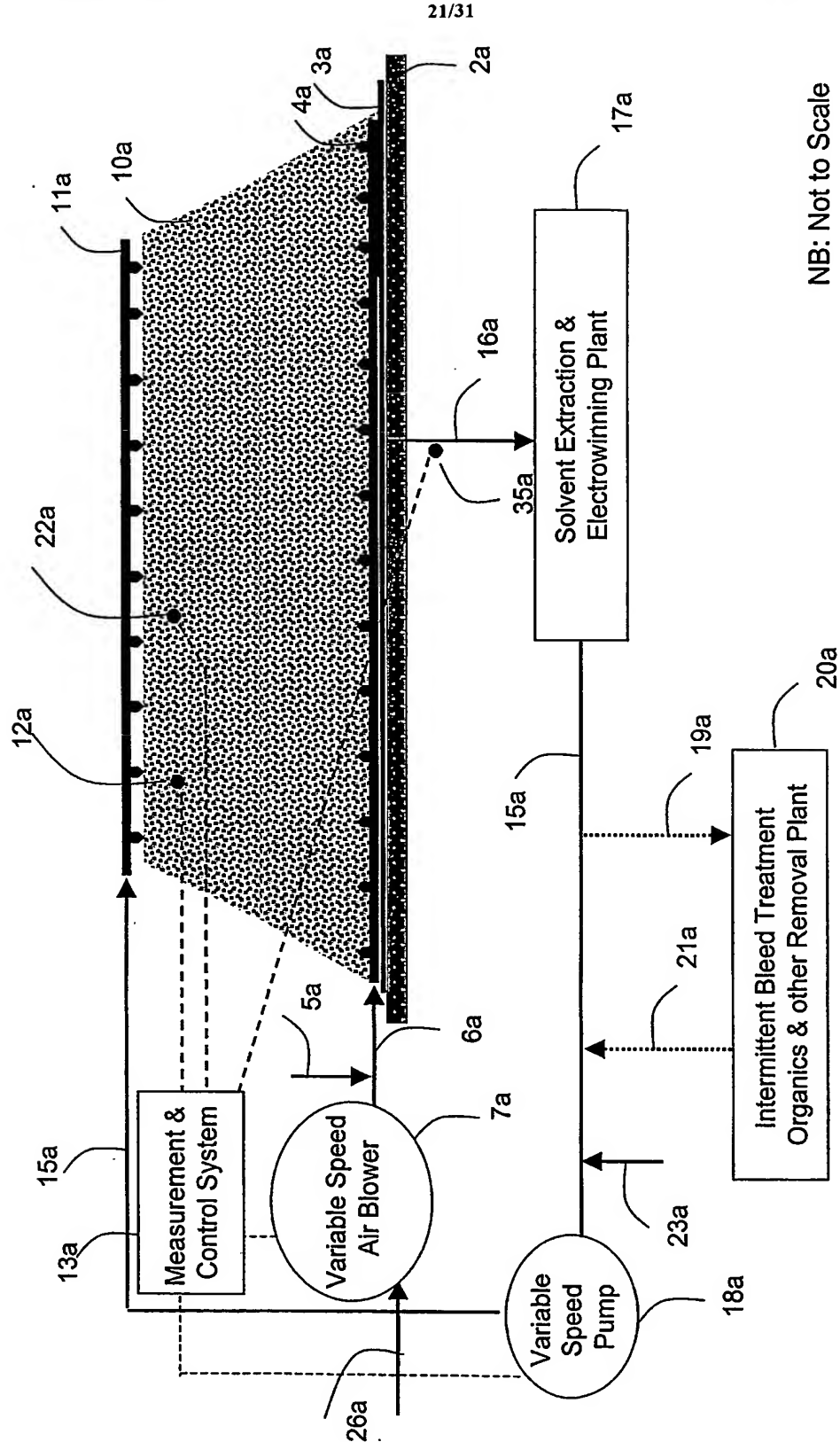


Figure 20 – Helping a heap to take-off: layer of granular material warming and humidifying air



NB: Not to Scale

Figure 21 - Illustration of operation in Example 1

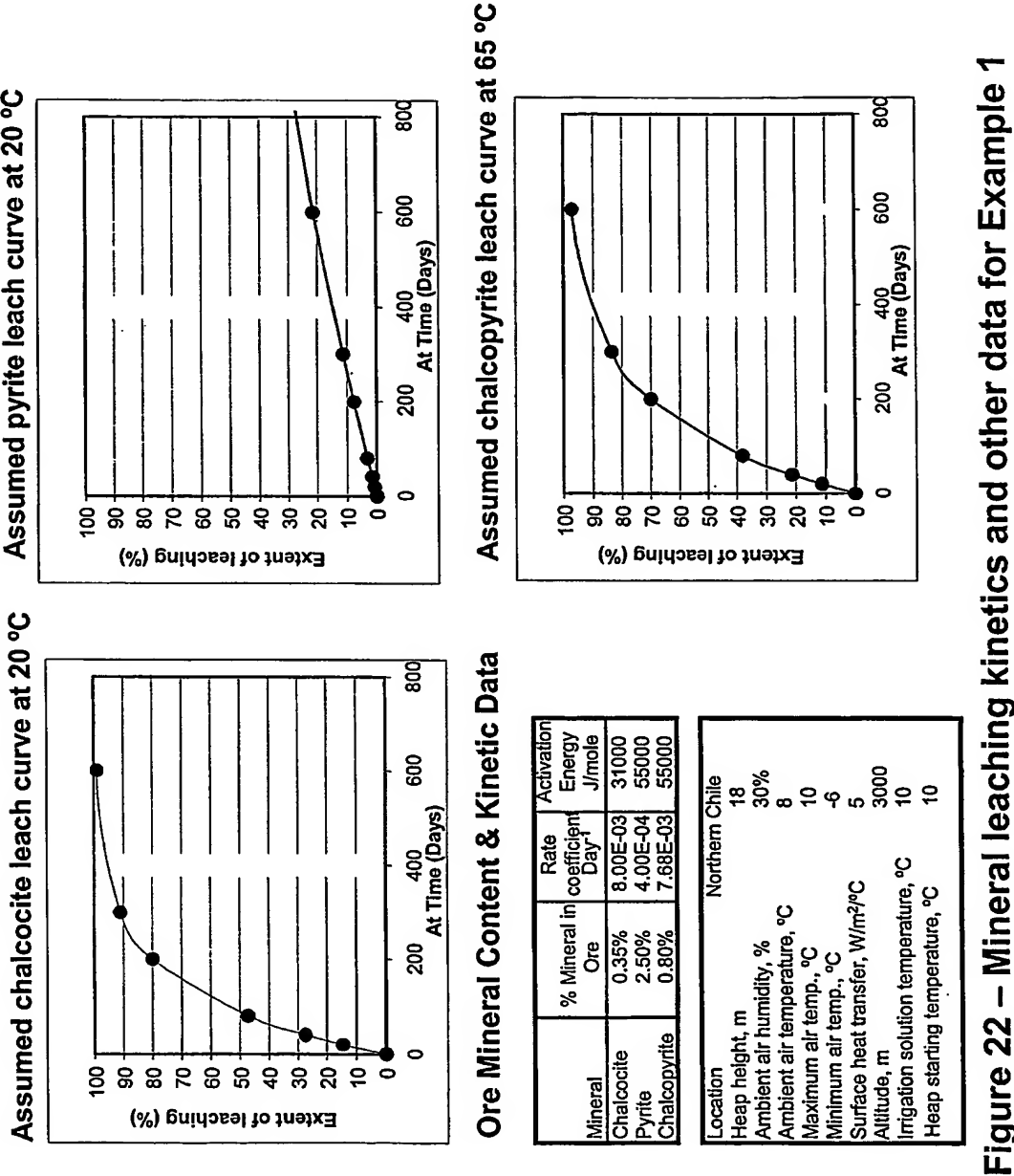


Figure 22 – Mineral leaching kinetics and other data for Example 1

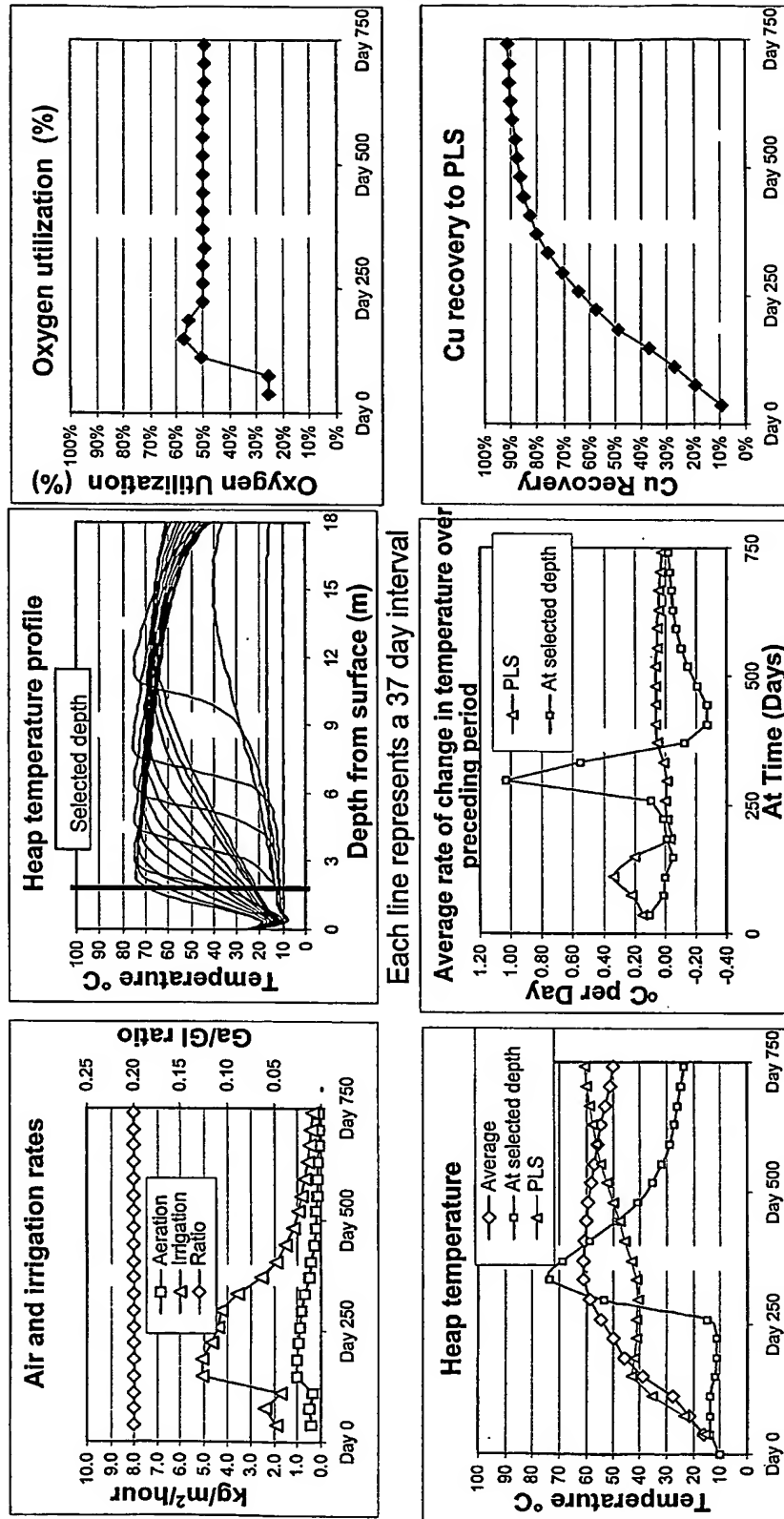


Figure 23 – Irrigation, temperature, oxygen utilization, copper recovery for Example 1

24/31

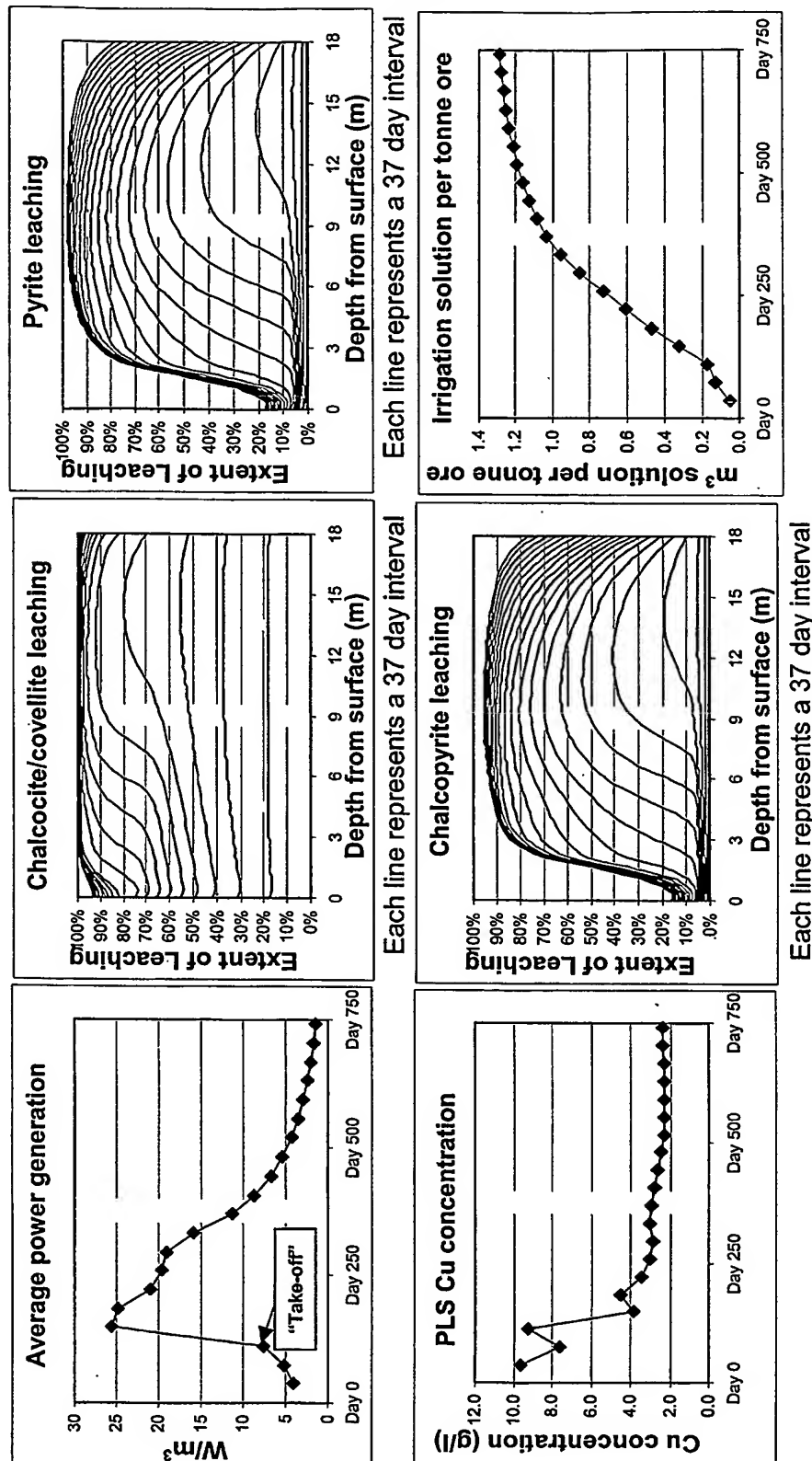


Figure 24 – Power, PLS copper, mineral leaching and irrigation application per tonne of ore for Example 1



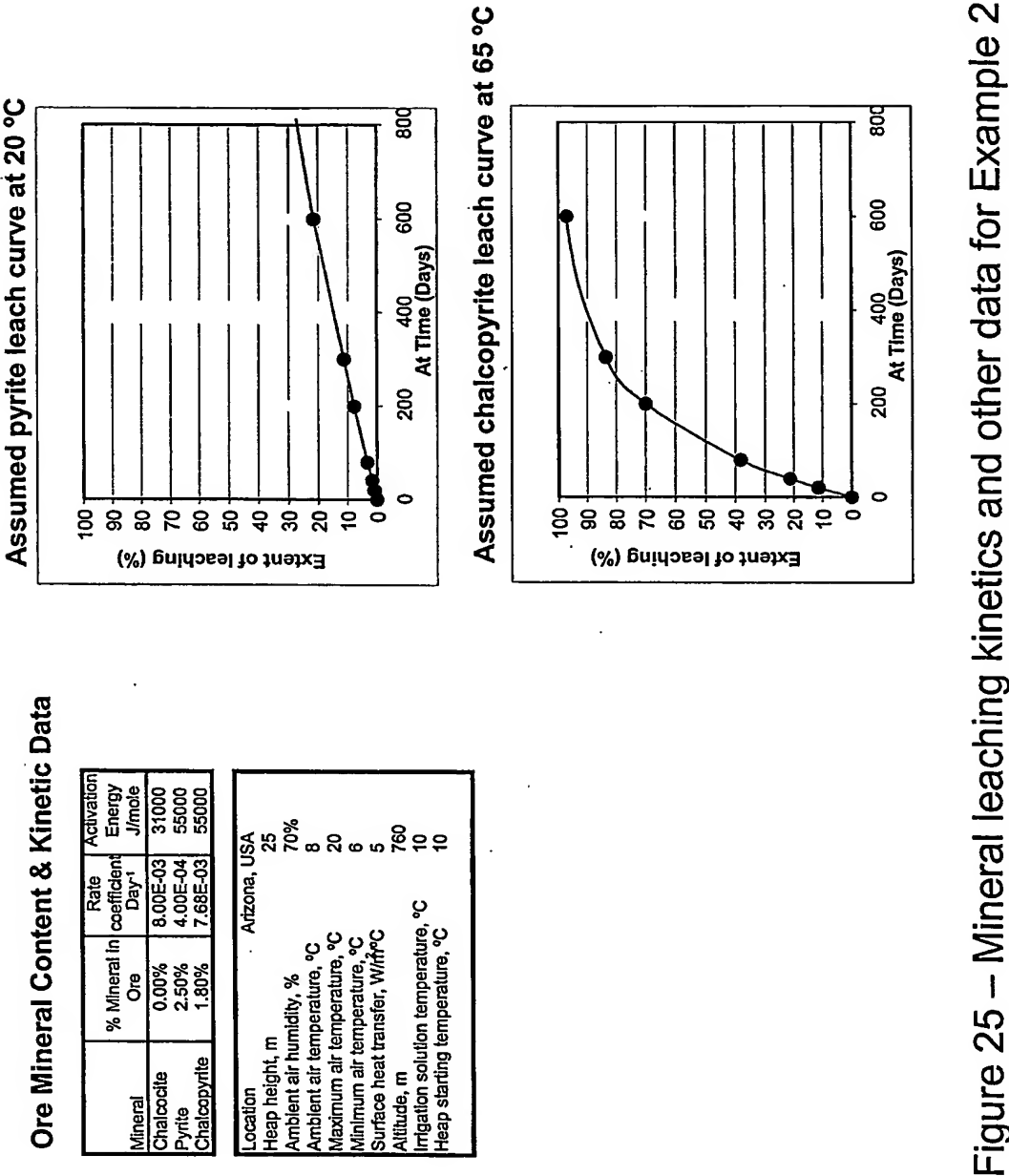


Figure 25 – Mineral leaching kinetics and other data for Example 2

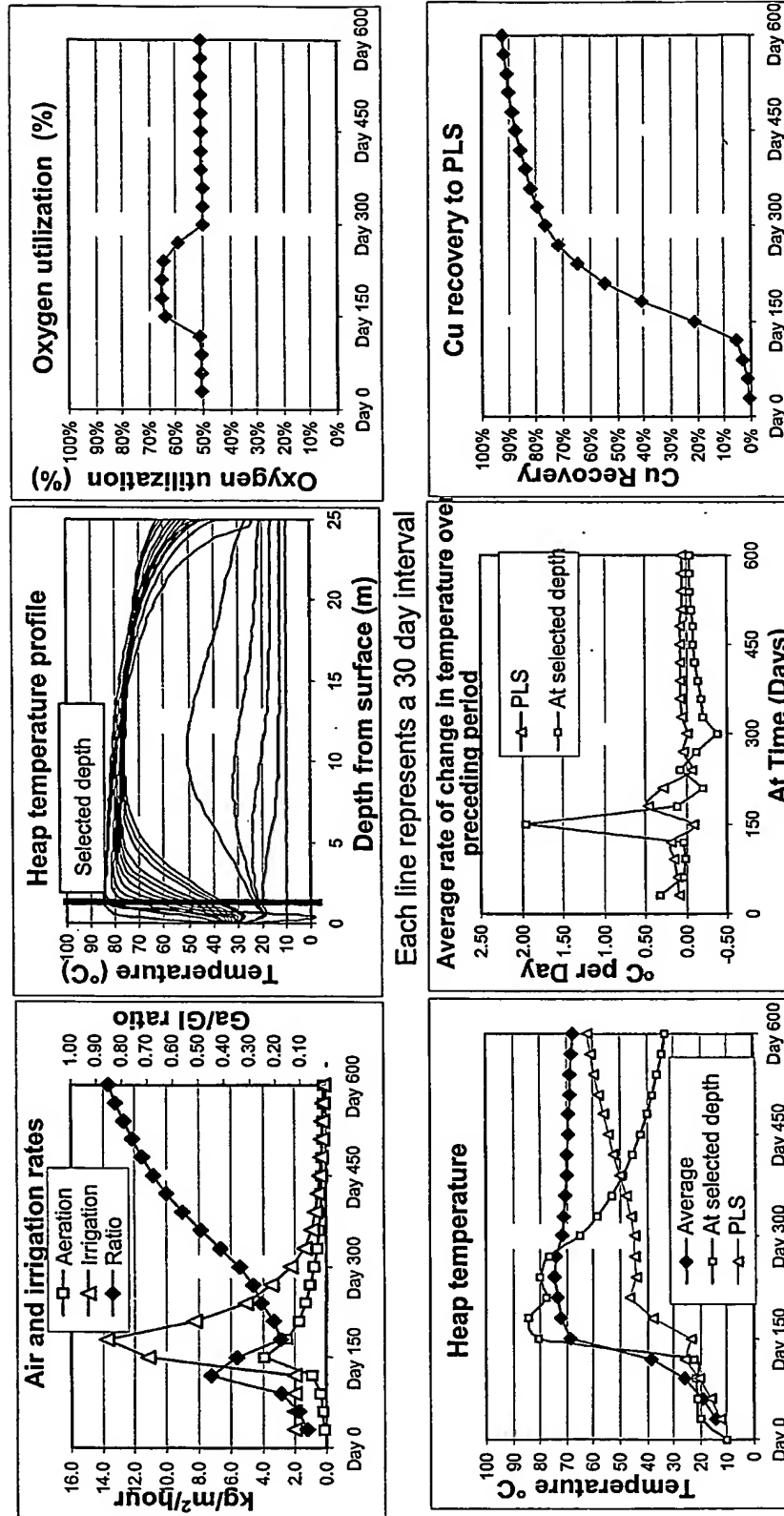


Figure 26 – Irrigation, aeration, temperature, oxygen utilization, copper recovery for Example 2

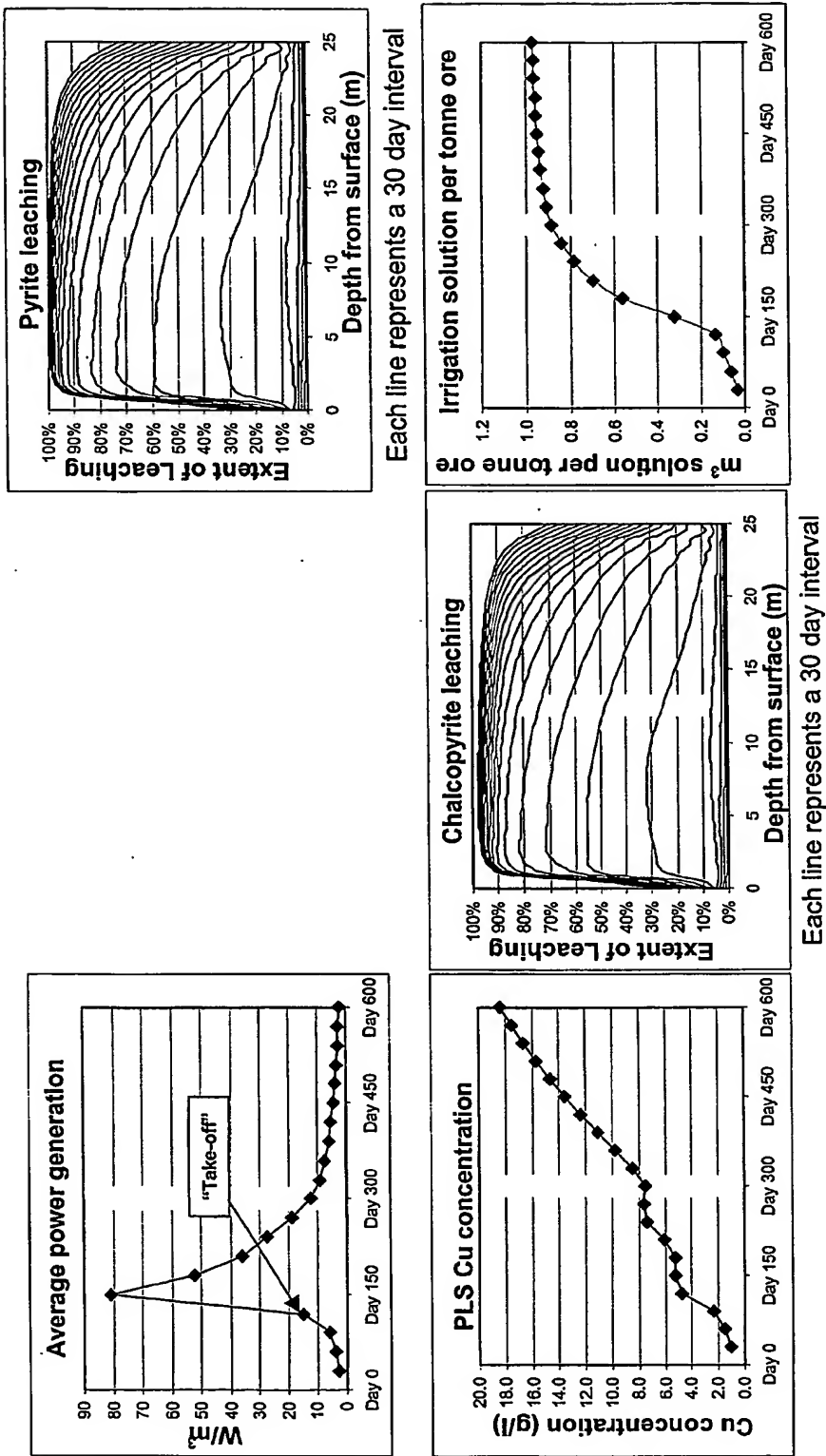
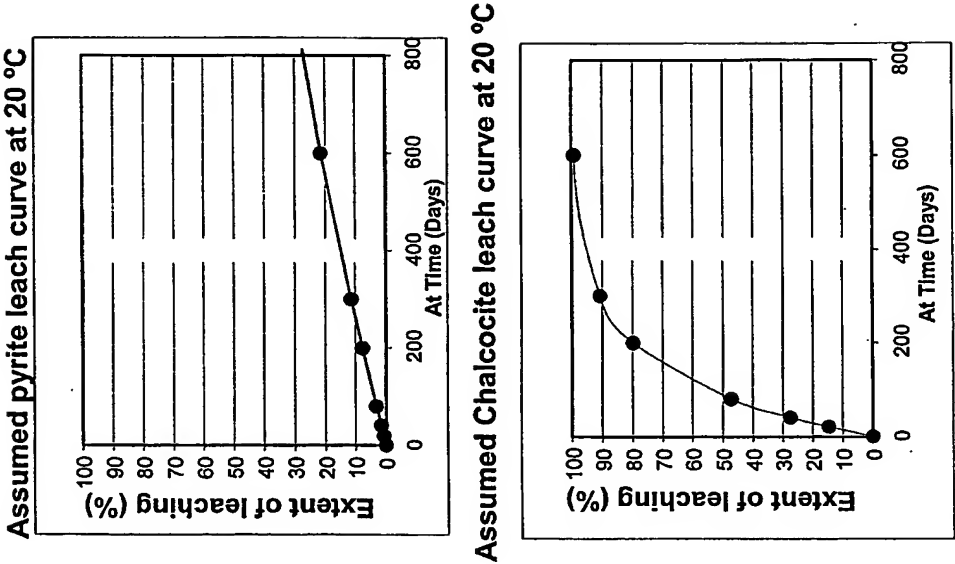


Figure 27 -- Power, PLS copper, mineral leaching and irrigation application per tonne of ore for Example 2



Ore Mineral Content & Kinetic Data

Mineral	% Mineral In Ore	Rate coefficient Day <sup>-1</sup>	Activation Energy J/mole
Chalcocite	1.20%	8.00E-03	31000
Pyrite	2.50%	4.00E-04	55000
Chalcopyrite	0.00%	7.68E-03	55000

Location	Northern Chile
Heap height, m	8
Ambient air humidity, %	30%
Ambient air temperature, °C	8
Maximum air temperature, °C	10
Minimum air temperature, °C	-6
Surface heat transfer, W/m²/°C	5
Altitude, m	3000
Irrigation solution temperature, °C	10
Heap starting temperature, °C	10

Figure 28 – Mineral leaching kinetics and other data for Example 3

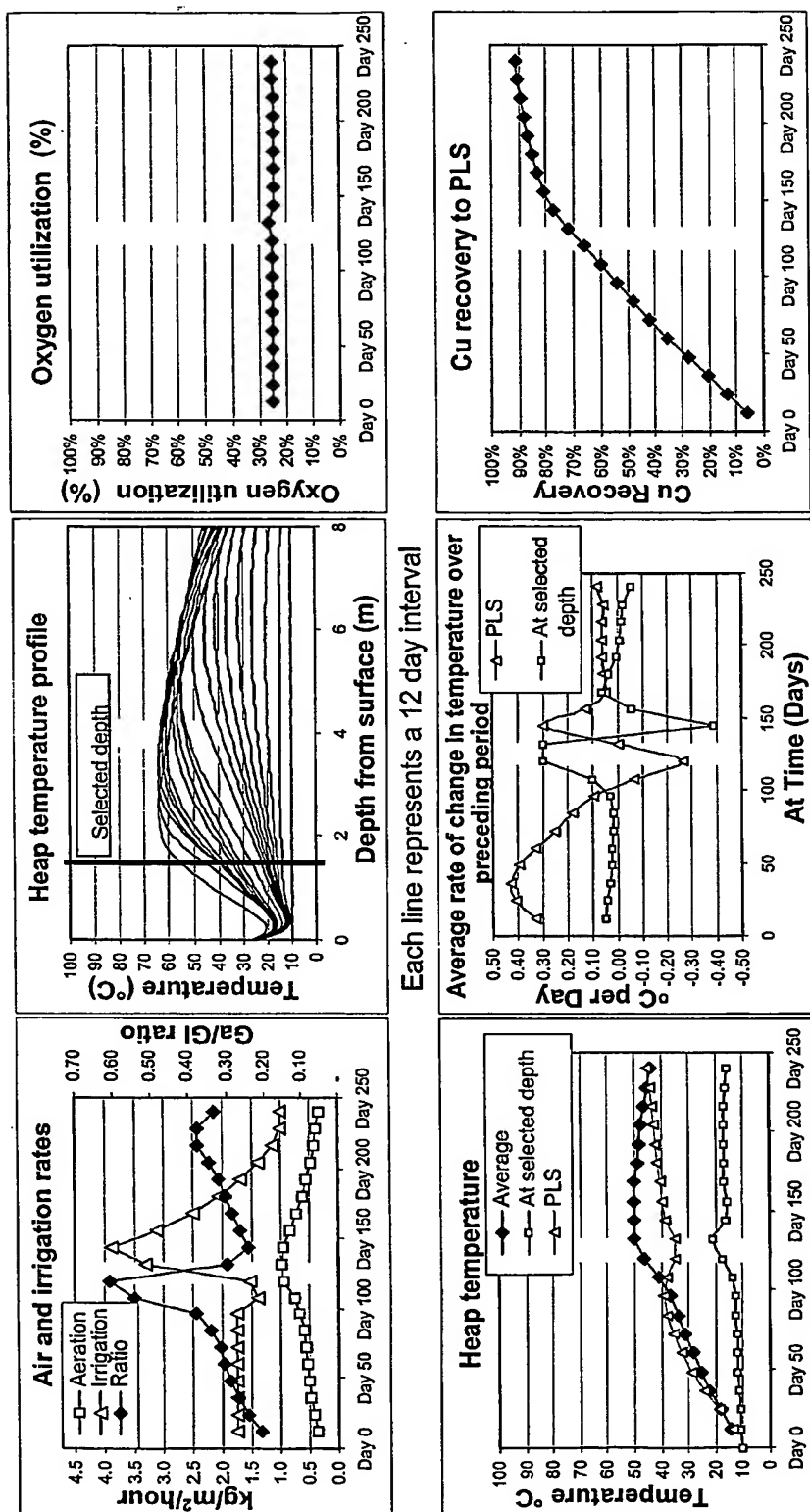


Figure 29 – Irrigation, aeration, temperature, oxygen utilization, copper recovery for Example 3

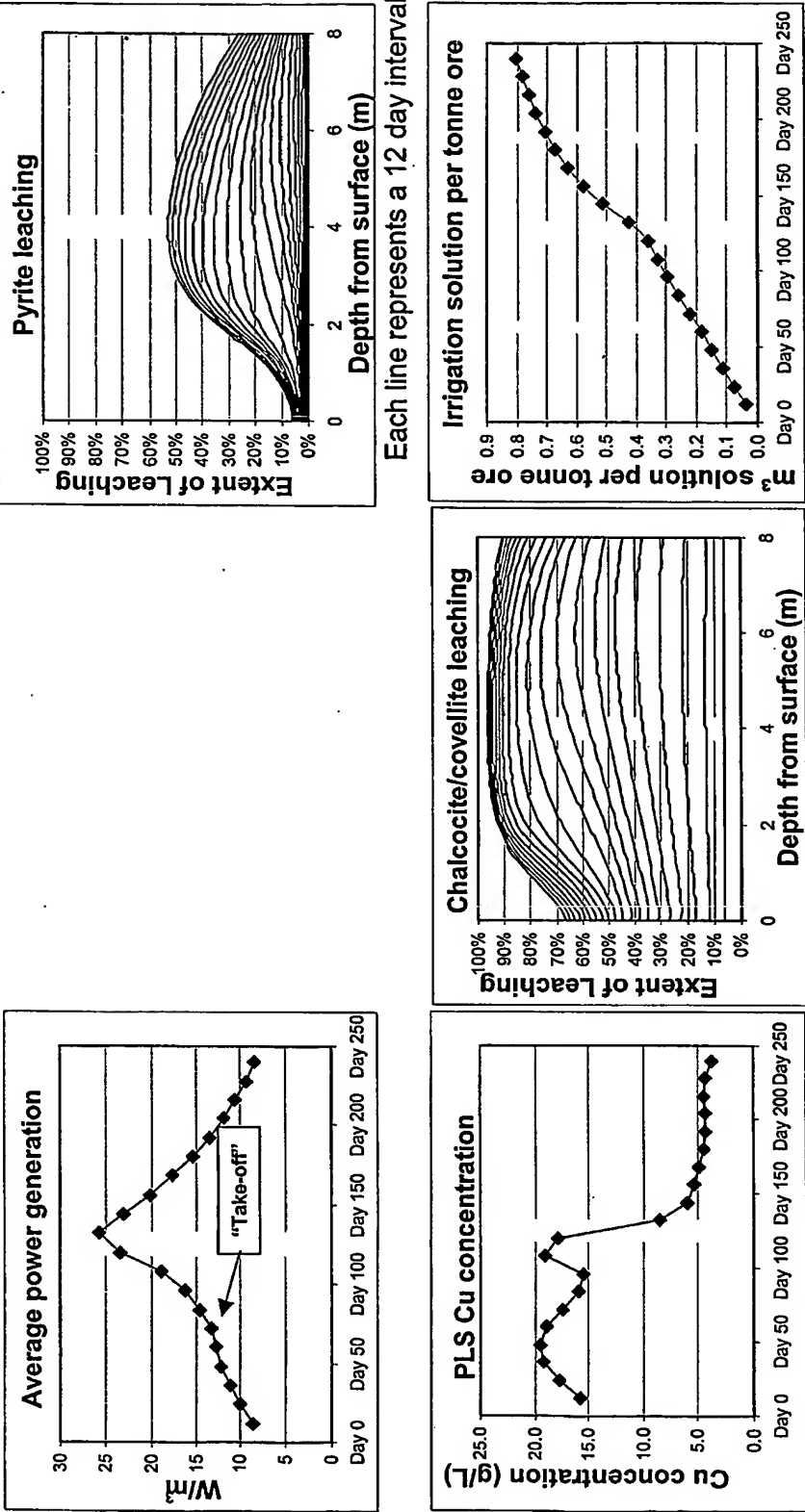
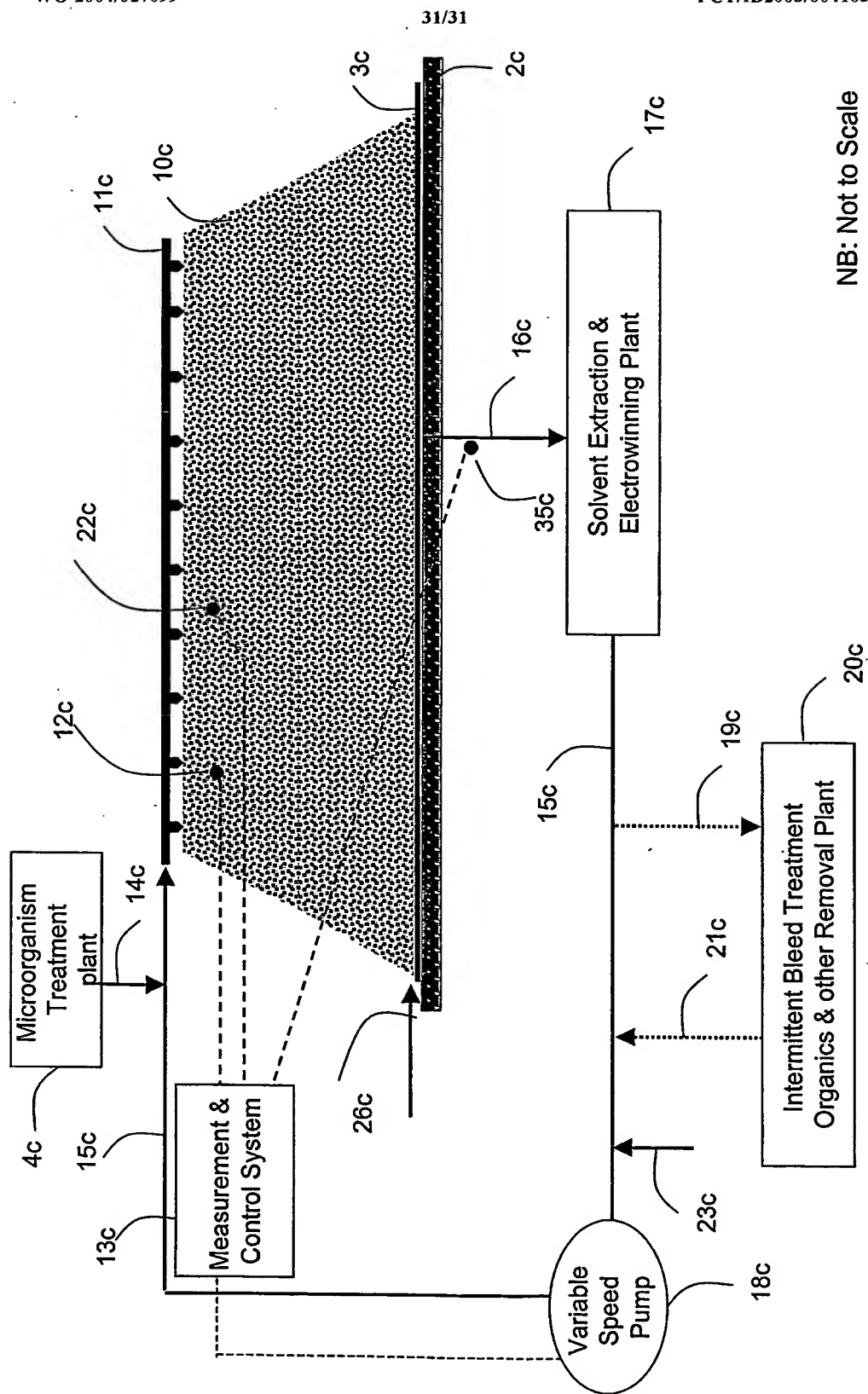


Figure 30 – Power, PLS copper, mineral leaching and irrigation application per tonne of ore for Example 3



NB: Not to Scale

Figure 31 - Illustration of operation in Example 4

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